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THE TEACHING OF MATHEMATICS IN THE SECONDARY SCHOOLS OF THE UNITED STATES.*

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Object of this paper. In accepting the kind invitation of your committee to present before the Educational Section of this International Congress a paper upon the Teaching of Mathematics in the Secondary Schools of the United States, I do so with five distinct objects in view. First: To set forth briefly the historic influences that have tended to make our mathematics in the West what it is at present; Second: To summarize the present status of the subject; Third: To mention the influences now at work to mould the secondary mathematics of the future; Fourth: To consider some of the resulting suggestions now being made to change the present curriculum; Fifth: To suggest a few questions that International Congresses of this nature might profitably consider through the medium of committees representing the leading educational countries.

HISTORICAL INFLUENCES.

That territory of the Western World now known as the United States of America, and called by its citizens, perhaps with undue assumption yet with pardonable brevity, America, was colonized chiefly by the French, Dutch, Spanish, and English. Before education assumed very definite form, however, the dominant spirit of the Anglo-Saxon had asserted itself to such an extent that the best part of our country was under British rule and subject to British influences. It therefore came about that Harvard University, founded in 1636, William and

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Mary in 1693, Yale in 1701, Princeton in 1746, and Columbia in 1754, were all based more or less upon the English models of the seventeenth and eighteenth centuries. Naturally too the elementary and secondary schools took on the characteristics of those of England, with such variations as local conditions demanded. The first secondary school planned for America was a Latin grammar school in Virginia, and the first one actually developed was a similar one in Boston in 1635, others soon following in various towns of New England. Even the Dutch settlers in New Amsterdam (the present New York) opened a school of this same character in 1659. It will thus be seen that the early secondary schools were classical in nature, profoundly influenced by the humanism of the Reformation, and little given to the development of mathematics. This was, in general, the situation when, owing to the greatest mistake that England ever made in her colonial policy, she lost control of her most valuable western territory, and the United States came into being. She had already, however, made her influence felt in mathematics, and we have by no means broken entirely away from it. In particular the American arithmetic was framed upon English models, a reprint of Hodder's book (1719) being the first work of this kind to appear in New England, and Greenwood's text-book (1729), the first purely American product, being based upon Cocker and Hodder. As a result, and also because of the influence of the common language, the American arithmetics have, until very recently, closely resembled the English type.

In geometry the same tendency was manifest. Early wedded to Euclid, the English schools paid no attention to solid geometry, so that even to-day, although Euclid as a text-book has long since been abandoned in America, none of our colleges on the Atlantic coast requires solid geometry for entrance to the arts course.

In algebra our text-books have always been based upon English models, and they are so to-day in spite of all of the many continental influences—and the same may be said for trigonometry.

In analytic geometry our treatises are largely the conics of Apollonius, modified it is true by the Cartesian treatment, but still embodying essentially the ancient sequence. In the calculus, it was only two generations ago that our college students worked in "Fluxions," the Newtonian influence having endured until that period.

Thus it is that our elementary and secondary mathematics were early influenced almost entirely by England, and that it took on those characteristics which, like all popular features, are not easily changed.

The separation from England, however, and particularly the second war (1812), led our young men to go to France, and later to Germany, rather than to England for their higher training. The result of all this was that the more advanced mathematics took on a continental aspect. Fluxions changed to the Calculus, even Euclid gave way to Legendre, conics became analytic geometry in name and treatment, although retaining its Apollonian limitations. Instead of advanced mathematics meaning the application of the calculus to mechanics, as seemed to be the Cambridge tendency, advanced pure mathematics began to call American students to France and still more to Germany. The latter country opened her universities to our young men more freely than France, and much more so than England, so that for the past quarter of a century German mathematics has nearly dominated the higher field. Göttingen has been our mathematical Mecca and Berlin our Medina, while Paris and Cambridge have, not altogether fortunately for the world, exercised a relatively small influence in the great West.

It will not do to dwell longer on these historic influences of countries or of schools. I wish, however, before I leave the topic to say a word as to the historic influence of different peoples upon American mathematics. America, I need hardly tell you, is the world's present meeting ground. Once all roads led to Rome; now many of them lead to America. Nearly a million immigrants come to our shores every year, and are assimilated into our body politic. Of aliens or of alien parentage, we have in the United States four or five times as many Englishmen as Liverpool, five or six times as many Germans as Berlin, nearly twice as many Irish as all Ireland, about as many Scotchmen as Edinburgh and Glasgow combined, three times as many Italians as Rome, and so for various other nationalities. These immigrants are not in general from the learned class, but they have energy, vitality, and a desire that their children shall have an education. They may not bring with them the mathematics of their various lands, but they accomplish two most important things for us: First, by crossing blood they make a cosmopolitan race of enormous energy; and Second, they give to the Amer-

ican of to-day a blood sympathy with the work of every country under the sun, and a mental tendency to look to other countries than England for educational models. And this brings me to my second topic, the present status of secondary mathematics in America.

The Present Status of Secondary Mathematics in America.

It is often thought that the United States, made up of some fifty state and territorial governments, with no centralized power in educational matters, must be without any uniformity in its schools. Such, however, is not the case. While the schools in the older portions of the country are more conservative in some respects, and while the wealthier sections have better trained teachers and more elaborate equipment as a rule, there is such a constant interchange of teachers and ideas, and there is such an influence exerted by organizations like the National Education Association and by the large text-book publishing houses, that the essential features in the teaching of mathematics do not vary particularly from one part of the country to the other.

In general the children attend public schools, more than ten times as many being enrolled in the public elementary schools and more than four times as many in the public secondary schools than in the private. Moreover, the public schools are growing much more rapidly than the private, and except in large cities the latter are hardly representative of American education.

The course usually consists of eight years in the elementary school (often in the cities, with some preliminary kindergarten work), four years in the high or secondary school, four years in the college (leading to the bachelor's degree), and three additional years in the university for the degree of doctor of philosophy. Of our total school population only 4¼% are in the high schools, and 1.4% in higher institutions of all kinds, less than 0.6% being in colleges and universities. It will thus be seen that while we have over 17,000,000 persons attending school, the number in college is relatively small.

In general, taking the country as a whole, it may be said that the work in mathematics is about as follows:

Elementary School. Years I-VIII inclusive. Five recitations per week. In the primary years, about 20-30 minutes each; in years V-VIII, 45 minutes each. Arithmetic, with men-

suration. In the last two years the linear equation with one unknown is used as an aid to arithmetic.

High (Secondary) School.

IX. 4 or 5 recitations per week, Algebra.

X. 4 or 5 recitations per week, Geometry.

XI. 4 or 5 recitations per week, Algebra and Geometry.

XII. Elective, Algebra, Geometry, and Trigonometry.

College.

XIII. 3 recitations per week. Algebra, Geom., and Trig.

XIV. Elective, Analytic Geometry and Calculus.

XV. Elective, Advanced Calculus.

XVI. Elective, Advanced or applied mathematics.

University.

XVII. Elective (Master's degree).

XVIII. Elective.

XIX. Elective (Doctor's degree).

Many schools attempt to introduce some constructive or other form of concrete geometry into the work of the elementary classes, but the effort has not as yet resulted in anything better than a more rational teaching of the elementary mensuration that has always had place in our curriculum.

I come now to the nature of the mathematical work in the secondary schools.

a. *The students.* It must be borne in mind that a great majority of the secondary schools in the United States are coeducational, practically all save in some of the cities. Boys and girls study the same mathematics and in the same classes. In the larger cities of the East, and in the private schools, this is not the case, and there is a slight tendency in favor of separating the sexes.

b. *The teachers.* The absolute freedom given to woman in America, her desire to be self-supporting, her willingness to work for a relatively low salary, and the better financial returns that other professions offer to men, have brought about an unfortunate condition with respect to teachers. While the woman is usually a better elementary teacher than the man, and while at the salaries now paid in America a secondary school can get a better woman than man, the best men teachers of algebra and geometry are better than the best women. The undesirability of having women in charge of pupils throughout their entire course is recognized, and in the cities every effort is made by

the school authorities to bring men into the secondary work in mathematics. With the natural increase in population of our country there will come less opportunity for men in other lines, and a reaction against the undue feminization of the schools, already manifest, will become more pronounced.

c. *The curriculum in detail.* The following is a brief statement of the New York City curriculum, a fair exponent of the work in other parts of the country:

Year IX. Algebra, 5 periods (45 minutes each) a week. Fundamental operations; linear equations with one and several unknowns; roots; indices; surds; complex numbers; quadratics with one and two unknowns; graphs of equations.

Year X. Geometry, 4 periods a week. Substantially the first four books of Euclid's or Legendre's geometry, studied from some modern text-book. At least 300 exercises in plane geometry. Geometric drawing.

Year XI. Geometry and Algebra, 3 periods. Plane geometry completed, covering substantially the ground of Euclid and Legendre, with exercises. Algebra through proportion, indeterminate equations, progressions, combinations, and the binomial theorem proved for positive integral exponents and used for others.

Year XII. Elective, 4 periods. Plane trigonometry and logarithms, or a review of mathematics, in the first half year. Solid geometry, higher algebra, and spherical trigonometry, or a review of mathematics, in the second half year.

d. *The influence of the colleges.* This curriculum is essentially what is demanded by the colleges, generally privately endowed institutions chartered by the various states, and all seeking to maintain a fairly uniform set of requirements. These colleges all admit students by their own examinations, most of them accept tests imposed by the College Entrance Board (a private coöperative committee made up of representatives of various colleges), and a large number admit on certificates from secondary schools of high standing. The result is quite the same, the colleges demanding practically the course above outlined, and forcing the schools to offer it. For better or for worse, the course stands, although a very small per cent of pupils complete it, and a still smaller per cent ever goes to college.

Influences at Work to Mould the Secondary Mathematics of the Future.

But this state of affairs is not to endure with us. A comparison of the educational literature of the past with that of the present shows that there has never been in America such a period of protest, of measuring each step of the curriculum, of experiment, and of the study of history of teaching, as the present. The secondary education of the country is on the eve of no small change, and the influences at work and the probable results may well occupy our attention as I bring this communication to a close.

a. *Influence of the elementary work.* The past ten or fifteen years have seen the work in arithmetic as greatly revolutionized as it was when the Pestalozzian influence reached America seventy-five years ago. This change has been brought about because of two considerations: (1) A growing interest in the psychological development of the child, resulting in a study of his mental aptitudes in the successive school years; (2) A growing interest in the real demands of business life, resulting in the substitution of modern applications for those of a remote past. This change has shown itself in the recent curricula and in the text-books which have of late appeared. The work is now commonly arranged on the basis of a conservatively drawn spiral, so that a child meets important topics two or more times, with increasingly difficult problems. Furthermore, without having any less abstract number work, the concrete problems are those that appeal to his interest, that represent genuine American conditions, and that relate to the life about him. The result has been a healthier attitude toward this subject on the part of pupils, teachers, and parents, and the question has naturally been raised as to whether it is possible to effect a similar reform in secondary mathematics.

b. *Foreign influences.* The study of foreign systems is also having a great influence on the present discussion. The continual stream of young men to German universities, the extensive study of European schools on the part of our educational leaders, the critical studies of curricula from all parts of the world that appear in the annual reports of the United States Commissioner of Education, and the dissemination of this knowledge by our higher institutions for the training of teachers—all this is con-

stantly bringing us in close touch with the world's best work. In my own classes last year I had students reporting upon the excellent curriculum in the Bulgarian gymnasium, upon the Mèray movement in France, upon the latest Prussian curricula, upon the work of the Italian *ginnasio,* and upon similar topics relating to other countries. Not an important change is made in any secondary courses in Europe that is not at once discussed in the leading teachers' associations in America, and not a theory is strenuously advocated, like that of Professor Perry of London, that does not receive serious attention in the New World. The result of all this continued inquiry into the best that other lands have to offer is a constant examination of our own work to see wherein it is capable of improvement. It is not particularly to our credit that this should be so, it is merely the force of circumstances, the result of the seething of mixing bloods in a new human reservoir.

c. *Commercial influences.* The American has, until the present time, been content to exploit his own country, to gather in the wealth of her virgin fields and forests, and to take the product of her easily worked mines. But now the country is filling up and we have within a generation, become a manufacturing people and have begun to look abroad for markets. The commercial spirit is rampant, and in the schools the constant question is asked, *Cui bono?* Hence the mathematics of the secondary schools is being continually called to account; its claims are being analyzed, and its results are being compared (with no common unit of measure, it is true) with the time devoted to the subject. This does not mean that mathematics is looked upon as purely utilitarian, for every one agrees that it has a high disciplinary value *per se,* but it means that there is a healthy demand for the substitution of that which has greater value for that which has less. In the matter of applications it means, to use a phrase from which I have often preached to teachers, that "whatever pretends to be practical should really be so," an idea that touches the keynote of an important present movement in America.

d. *Psychological influences.* There is another influence that is bound strongly to mould the future, and that is the intense study of practical psychology. Teachers are asking why the human mind should be asked to comprehend certain exceedingly abstract principles of geometry before the much easier

parts of trigonometry are mastered; why the intricacies of advanced algebra are required before the simpler parts of the calculus are presented; and why, in general, there should be the conventional and accidental barriers maintained between algebra and geometry, geometry and trigonometry, and algebra and the calculus. I do not mean that these questions are not capable of answer, but that we are doubting whether it is a sufficient answer to say, "*Laissez faire.*"

e. *Scientific influences.* There is also the influence that natural science is bringing to bear upon mathematics. Since our subject is needed in physics, physics is held to be especially joined with it, and extremists are not wanting who would go so far as to link the two together at every step. Out of this agitation, still in its crude and extreme phase, not a little good will come.

f. *The dogma of thoroughness.* Whether it be British conservatism that is at the bottom of the case, or some mistaken desire to exhaust every step before the next is taken, it sometimes seems that in no other country save England is the dogma of thoroughness so much in evidence. Our geometry is much more hair-splitting than that of Germany, although we do not produce so good geometers; our algebra covers many more details than the ordinary French text-book, yet we do not produce so good algebraists; and our trigonometries are quite as thorough as those of any other country save England, and yet our students are not particularly brilliant in this field, save only when they apply it to engineering. Whether this is a justifiable state of affairs may seriously be questioned. Educators are, therefore, asking if better results may not be attained by greater area and less depth, by introducing some plane trigonometry in place of part of the extensive treatment of plane geometry, and by giving a little insight into the calculus in lieu of part of algebra, just as curve tracing (graphs) is now introduced to give a slight notion of analytic geometry.

Suggestions of Change in the Curriculum.

Out of all the discussion relating to secondary mathematics in the United States come numerous suggestions of change. I propose to summarize these, not as indicating what is to happen in the immediate future, but as showing some of the tendencies. I shall set forth a course that embodies many current ideas,

although one that has been recommended by no body of teachers and adopted by no school. Its purpose is merely to provoke discussion and to show some of the views of a rather advanced line of educators in Amerira. It is arranged for five years—the last year of the elementary school and the four years of the secondary school.

YEAR VIII. Mathematics I. Required. Boys and girls together. Five periods per week.

General view: Transition from special to general forms. A combination of algebra, concrete geometry, and arithmetic. Algebra the basis for the arrangement of the course.

Detailed view:

1. Algebraic formulas.
   (a) Application to mensuration, always leading to a formula to be manipulated like an equation. (Simple work in square root to follow later in the year.)
   (b) Application to business customs, as in interest, discount, and commissions.
   (c) Application to statistics. Graphic representations with squared paper, both when the formula is given and when only the statistics are known.
   (d) The notation of simple functions, as that interest on a given principal at a given rate is a function of the time; that the area of a circle is a function of the radius, etc.
   (e) Sufficient simple experimental work to show the law of the lever, with its formula. This may reasonably lead to introducing other simple formulas of physics, without experiment, to show certain uses of algebra. E. g., the formula for the strength of a steel beam.
   (f) In the numerical evaluation of functions, as in $c=2\pi r$, to introduce the slide rule and the check of 9's and 11's. The underlying principles of the checks may be postponed until Mathematics V (b) is studied. The metric system used now and in all subsequent work in which science problems are involved.
2. Linear equations with one unknown.
   (a) Applications to problems of arithmetic, with a discussion of the advantages or disadvantages of the algebraic symbolism.

(b) Application to mensuration as before.
(c) Mathematical recreations, bringing out the same element.

3. Algebraic functions and the fundamental operations.
   (a) Apply the work as much as possible to the formulas studied above.
   (b) Factoring, using geometric correspondence where it is helpful. Comparison with arithmetic. Apply this work to solving easy quadratics, including application.
   (c) Fractions, reviewing at the same time the principles of and practice with numerical fractions.
4. Linear equations with two unknowns.
   (a) Applications to arithmetic.
   (b) Also to mensuration as above.
   (c) The recreation phase considered.

YEAR IX. Mathematics II. Required. Boys and girls in separate classes, with the possible proviso that girls may elect to enter the classes for boys. Five periods per week.

General view: Elementary algebra through quadratics with one unknown, combined as closely as possible with the first three books of plane geometry, each presupposing Mathematics I and building directly upon it. No definite allotment of hours to either as related to the other subject is to be made for the year, but this is to be regulated by the teacher as experience shows to be necessary. This should be the final required course for the girls. The concrete geometry now passes into the demonstrative. The correspondence between algebra and geometry is to be emphasized. The practical applications of each subject are to be made as real as possible. It is recognized that the success of the course depends upon the teacher's ability at this point to use the existing text-books on algebra and geometry in the spirit here suggested. Text-books combining algebra and geometry are not to be expected in the immediate future, even if they are to be desired (which is still doubtful). It is probable that the time will be divided about equally between algebra and geometry. Five hours may be given to each every two weeks, alternating day by day, or, preferably, each lesson may include both topics. The field is a new one, and this is one of the points for serious experiment.

Detailed view:

1. Book I of plane geometry, the book propositions being limited to those required in the recent syllabi.

   (a) Use of protractor; drawing to scale. Mechanical drawing begun in the art and manual training courses and applied to this work now and throughout the rest of the course. The construction of simple instruments for angle measure. Primitive methods of measuring distances based on Book I.

   (b) Mensuration whenever advantageous.

   (c) Original exercises, with a beginning of generalization whenever practicable. E. g., derive the laws of the equilateral triangle from those of the isosceles; consider the rectangle with respect to the parallelogram; consider the exterior angles of the various forms of the triangle.

   (d) Experiment upon the relation of solid geometry to plane, guided by Mèray and de Paolis, carrying the work only so far as is positively advantageous.

2. In connection with the above, and related to it as far as possible, there should be a brief review of the operations on algebraic functions, with applications when they can be found, and a review of linear equations with one and two unknowns in the same spirit. The graph of linear equations with two unknowns, for the purpose of bringing out the meaning of "linear" and "simultaneous," and incidentally of picturing roots in general. Graphic solutions of train problems as related to this work.

3. Book II of plane geometry (Euclidean sequence), treated only briefly as illustrating familiar algebraic forms. E. g., $a(b+c)$, $(a+b)^2$, and a few similar forms, should be taken up as matters of interest during the class period. It is intended that there shall be no strict geometric treatment of this book.

4. Book III of plane geometry, omitting generalizations that are too difficult for this year. Relate the work to the quadratic, particularly in the applied problems.

5. Algebraic problems involving quadratics that relate to the geometry of this year, and (as far as possible) to other work of this class. E. g., if manual training can offer any problems, or if any simple mechanical laws can be illustrated to the class, advantage should be taken of this work.

6. As far as possible, the applications of geometry and algebra

should be selected, for the boys, from mechanics, mensuration, and commercial life; for the girls, they should relate to designing, and to the domain of domestic arts and sciences as far as can reasonably be arranged. For the girls particularly, the work given in a book like Becker's *Geometrisches Zeichnen* is very valuable.

7. When the laws of exponents are taken up, logarithms should be introduced and tables thenceforth used practically, as the slide rule has already been used. Comparison of these two aids to calculation. Each should be used whenever numerical computations are involved, as in evaluating expressions involving radicals.

YEAR X. Mathematics III. Required for boys; elective for girls. Separate classes. Five periods per week.

General view: Elementary algebra completed, through quadratics with two unknowns, and variation. Plane geometry completed, condensed as in Mathematics II. Mechanical drawing continued in connection with applied work. The trigonometry of the plane triangle in connection with similar figures. Practical mensuration of plane and solid figures, with the help of trigonometry. The use of the transit. Solid geometry combined with plane as far as reasonable.

Detailed view:

1. Algebra through quadratics with two unknowns. Graphic work to illustrate the following:
   - (a) The nature of the roots (imaginaries entering in pairs, etc.)
   - (b) Number of roots to be expected.
   - (c) The three forms of the conics (the names being given).

2. The study of variation to include not an undue amount of simple experimental work in physics, together with related problems in mensuration. The regular work in physics this year to be related as closely as possible to this work.

3. Plane geometry completed. Ratio and proportion taken up for algebra and geometry at the same time. Limits and incommensurable cases considered only incidentally, no attempt being made at strict proofs.

4. Similar figures to lead to the trigonometry of the plane triangle. Use of simple instruments to be constructed by the class, such as the "riga," "baculus," "quadrans," "speculum."

etc., followed by the use of the transit and plane table. Computations in mensuration and physical problems to be performed both by the slide rule and by logarithms.

5. The mensuration of solid geometry.

6. As far as possible, problems for the boys should relate to business, mechanics, physics, and practical applications to the mensuration of land and buildings; those for the girls (in their elective course) to domestic economy, including designing, sanitation, and civic questions that touch the home.

YEAR XI. Mathematics IV. Elective for both boys and girls. Separate classes preferred. Five periods per week.

General view: A course leading to mechanics and physiography and introducing the spherical triangle, the elements of analytic geometry and curve tracing generally.

Detailed view:

1. Relation of the work to physics. The work in physics this year is usually of a laboratory nature. The teachers of mathematics should be in constant touch with this work with a view to securing problems and to supplying the necessary mathematics at the proper time.

2. Mechanics should enter into the applied work as extensively as possible. Mechanical drawing continued as heretofore, and the ability secured to read a working drawing.

3. The course in physiography often given in the 12th school year should be transferred to this year and brought into close relation to this course. Study of simple map projections, and the applications of trigonometry and geometric drawing to physiography. Determination of latitude by observation of the sun and the polar star. Computation of local time and of longitude. Computation of great-circle arcs from given latitudes and longitudes. All this should be the objective work in the study of the spherical triangle.

4. Analytic geometry. The fundamental theorems relating to the conics, this course being, like the work in elementary geometry, condensed as much as possible. The study of curves used in mechanics and physics, with applications to such matters as the catenary corrections in steel taping.

5. A review of the essential theorems of geometry and trigonometry. Approximation formulas, such as Simpson's rule for areas.

6. Practical field work with the transit.

YEAR XII. Mathematics V (a). Elective for both boys and girls. Separate classes preferred. First half year (see also Mathematics V (*b*), below). Four periods per week. Prerequisite, Mathematics IV.

General view: A half year of work in the calculus and its applications, with practical work in the use of the transit and with abundant applications to mechanics. It is possible that a parallel culture course for girls may be arranged, involving the elements of mathematical and descriptive astronomy.

Detailed view:

1. The elements of differential and integral calculus, with practical applications to mechanics. Such cases in mensuration as have thus far been treated rather unsatisfactorily should now be clearly understood; *e. g.*, Simpson's rule.

2. Field work in the use of the transit. Railway curves, simple bridge building problems, and other applications of trigonometry and the calculus.

3. Applications for the work of V *(b)*, as in the laws of probabilities and least squares.

Mathematics V *(b)*. Required for boys, elective for girls. Separate classes. Three periods per week throughout the year. prerequisite, Mathematics III.

General view: Commercial arithmetic. A thorough course, three periods per week for the entire year, embodying all the commercial arithmetic needed by a man entering business. To include as much as possible a review of Mathematics I, II, III, and to cover all the common business applications of to-day. Elements of bookkeeping. All obsolete and non-utilitarium matter to be eliminated. For the girls, particular attention to the arithmetic of the various branches of domestic economy, including household accounts and investments, and household chemistry.

Detailed view:

1. Computation. Review of the slide rule and logarithms. Calculating machines explained and their uses set forth. The underlying principles of the checks of casting out 9's and 11's.

2. Theory of investments. The practical questions of compound interest, annuities, and investments in stocks and bonds.

3. Banking and exchange.

4. The simpler parts of the mathematics of statistics. Possibly the method of least squares with practical applications to science.

5. The construction and use of practical tables, such as interest, wage, exchange, temperature, longitude, tax, etc.

6. A brief treatment of the theory of fire and life insurance, involving the first principles of probability.

7. Fundamental principles of commission, brokerage, discounts, and other business customs.

I should add that some such course is now under contemplation in the Horace Mann School of Observation, Teachers College, Columbia University, New York City.

QUESTIONS FOR THE CONSIDERATION OF SUCH CONGRESSES AS THIS.

And now, in closing, I should like to express the hope that these International Congresses may add to their already great value as clearing houses of thought, by some time investigating, through committees, a few questions relating to secondary education. Countries cannot be uniform in their curricula, their school systems, nor their methods of teaching, but the influence of a Congress like this might greatly help many who are earnestly seeking to improve the teaching of mathematics. Some of the questions that might profitably be considered are the following:

1. What have been the results of attempting to remove the barrier between such topics as algebra and geometry, or to teach the two simultaneously, and are we prepared as yet to make any recommendation in this matter?

2. What have been the results of attempting to teach demonstrative geometry before algebra? If they have been favorable, what is the nature of the geometry best adapted to this apparently psychological sequence?

3. What is the opinion of impartial observers of the work of the Méray geometry in France and of works like that of de Paolis in Italy, as to the union of plane and solid geometry?

4. What is done in the various countries as to the union of plane geometry and trigonometry?

5. What is being done to advantage in the introduction of the elementary ideas of the calculus into the work in secondary algebra?

6. What is the safe minimum of Euclidean geometry as the basis for work in analytic geometry, the calculus, and mechanics?

7. What is the safe relation to be established between secondary mathematics and physics?

8. What position should the secondary schools take with respect to the nature of applications, and the relations of applied to pure mathematics?

9. What should be the relative nature of the courses in the secondary schools for those who do not intend to proceed to the universities, and for those who do intend to do so? In other words, of finishing *vs.* preparatory courses?

These questions, and others like them, are occupying the serious thought of American teachers. As we have always turned to Europe for conservative but helpful suggestions, so some of us would be glad if this Congress might deem it advisable to appoint international committees, corresponding in any of the four languages admitted to these meetings, to consider matters of this kind.* An agree ment is not essential, but the interchange of views and suggestions could not fail to be very helpful.

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*As a result of this suggestion the International Commission on the Teaching of Mathematics was appointed by the Congress.

A DISCUSSION OF THE REPORT OF THE COMMITTEE ON ALGEBRA.*

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The widespread agitation in respect to the teaching and content of secondary mathematics has, I believe, already resulted in considerable improvement in the teaching of the subject. There are, however, some dangers in the agitation. It gives a splendid opportunity to the man of one idea, though, fortunately, we have few of these teaching mathematics. There is no great harm in this. But a man has worked along a new line and his faith and enthusiasm in the departure he is making have made his work eminently successful. Others following in his tracks but without his faith or enthusiasm make a failure. I mention this because a report that is likely to be adopted in whole or in part by a large number of teachers ought to be conservative and to contain few, if any, suggestions of changes that are not likely to prove successful in the hands of the average teacher using the text-books at his disposal.

The present report is to be commended in this respect. The committee has evidently given the subject careful consideration and suggested only changes that have met the approval of a large number of teachers. The committee very wisely makes it clear that the most of the recommendations are suggestive only. What may be best for one class is not for another. What is best for one teacher is not for another, and were it possible to have classes exactly alike, the wise teacher will, from year to year, vary both the mode of presentation and, to a less degree, the subject-matter.

I am in hearty sympathy with most of the suggestions made I am inclined to disagree with the main purpose of the first course. As Professor Cajori points out, early in the last century too much emphasis was laid upon the solution of problems and in the reaction the pendulum swung too far the other way, and now, as it is swinging back, there is danger that the place of the problem will be over magnified. The problem should have a larger place in the elementary course, but, in my opinion, not the chief place. I agree with Professor Stone when he says,

*Read before the Mathematics section of the C. A. S. & M. T., November 28, 1908.

"The power to interpret fully the meaning of the general numbers of a formula or of an identity is of greater value than the power to solve a problem."

Some may object that this is too difficult for the beginning pupil. He must of necessity begin to interpret at the commencement of his study of algebra, and this phase of the work should be kept in mind throughout the course, and his progress is measured largely by his progress in this direction. It is true the problem gives excellent drill in this work, and in other respects it has great disciplinary value, and if problems are so chosen and arranged that the algebraic principles are developed from them, as Professor Slaught suggests, the place of the problem will be greatly enhanced. Nevertheless its place is, in my opinion, a subordinate one.

It must not be lost sight of that much of the mechanical work ought to be done at as early an age as possible, hence a secondary aim in the first course must be the acquiring of skill in the mechanical work. If the work is carried out wisely, I believe it has much more disciplinary value than is generally credited to it.

How much demonstration work would best be given will depend upon the class; as a rule, not much, but just what the majority of the class can get hold of without undue waste of time. The teacher should not insist too strongly on the pupil giving formal proofs, but, as the report suggests, he should be led to see the reasonableness of the principles.

I agree with the committee quite well as to the topics that may be omitted in the first course. If square root of polynomials is taken, I prefer to give a little work in cube root to show that the method of extracting this root is developed in the same way as that of square root. The teacher may find it wise at times to take up one or more of these topics in a first year course but, as a rule, I believe it best to omit all of them.

I question the wisdom of teaching multiplication and division together. It seems best to me to give a considerable drill on multiplication, introducing division incidentally that the pupil may be prepared when he comes to it. Then when long division is studied, by all means bring out its relation to multiplication.

I have the same thought in regard to teaching exponents and radicals. I prefer to teach exponents first, and then, in the study of radicals, make free use of the fractional exponent and

call attention to the fact that the radical is unnecessary; and that were it not that the radical was in use before the exponent, we probably would not have the radical form.

I am glad for the suggestion of the early introduction of the quadratic equation. The solution by factoring immediately after factoring indicates a use for the latter and a use that delights the pupil. In addition to this, it introduces a method of solving equations that is applicable so far as it is possible to find linear factors. We often find the solution by factoring either omitted altogether or barely noticed after a considerable drill in completing the square has been given. The early introduction makes the more thorough mastery of the quadratic equation probable.

In the selection of problems, the more satisfactory problems we can get from the sciences, from geometry, and from everyday life and experience, the better. Our problem sets unquestionably need enriching; but care must be taken to see that the problems chosen are not too long in statement and that the terms used are understood by the pupils. The old, time worn problem that tells its story briefly and to the point is preferable to the modern problem that tries the patience of the pupil to read it through.

Many of the formulæ of physics and geometry can be given and should be solved for each of the letters used, but in choosing problems from the physics, I should be even more cautious than the report suggests. I realize that under ideal conditions for such an experiment the physics and algebra may be worked out side by side successfully, but choosing problems from the physics before the pupil has studied the subject is likely to result in loss of time and may tend to create a dislike for both physics and algebra.

In closing I wish to say that I am in hearty sympathy with the movement to unify secondary mathematics. A larger use of arithmetic and algebra in geometry and of geometry in algebra are steps in the right direction and will prepare the way for a still closer union of algebra, geometry and trigonometry. I have faith to believe that a course in secondary mathematics can be worked out that will have many advantages over our present course and few if any disadvantages.

ON THE COMPUTATION OF COMMON LOGARITHMS FOR BEGINNERS.

By Robert E. Moritz, Ph. D.,

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When the student of elementary mathematics first reaches the conception of logarithms and perceives the tremendous advantages of the new method of computation, the question frequently arises, "How do we get logarithms?" and the usual answer to the question is that the computation of logarithms is a complicated process which requires the use of infinite series, a knowledge of which the student has seldom acquired at the time when he first reaches the subject of logarithms.

Some authors do indeed deduce the logarithmic series by means of which natural logarithms may be most easily calculated, and show how from a table of natural logarithms a table of common logarithms may be obtained, but owing to the indirectness of the process, and perhaps still more to the student's unfamiliarity with infinite series, this method of constructing a table of common logarithms is seldom understood by the beginner and usually leaves him with the impression that there is something intrinsically difficult and incomprehensible about the whole matter. Certain it is that the majority of students who have studied logarithms and who have acquired a reasonable familiarity with their use in computation, have a confused notion of the true nature of logarithms. There can be no doubt that it would at least help toward a better understanding of the subject if the student could be shown how to compute a table of logarithms by processes with which he is perfectly familiar.

Some continental text-books present what is known as the Briggs-Napier method of computing logarithms, the method suggested by Napier to Briggs, who employed it in the construction of the first table of common logarithms. This method employs the extraction of square roots only, but requires a knowledge of the theorem that if a series of numbers form a geometric progression their logarithms form an arithmetic progression. It follows that the logarithm of the geometric mean of two numbers is the arithmetic mean of their logarithms. Now the logarithms of the numbers 1 and 10 are known to be 0 and 1 respectively, hence the logarithm of the geometric mean of 1 and 10 is known to be ½, thus

$$\log \sqrt{1 \times 10} = \log 3.16228 = .5$$

Similarly

$$\log \sqrt{10 \times 3.16227} = \log 5.62341 = \frac{1 + .5}{2} = .75$$

$$\log \sqrt{3.16227 \times 5.62341} = \log 4.21696 = \frac{.75 + .5}{2} = .625$$

$$\log \sqrt{5.62341 \times 4.21696} = \log 4.86967 = \frac{.75 + .625}{2} = .6875$$

and so on at pleasure.

The present writer in presenting logarithms to beginners uses the following method, which while perhaps not essentially different from the Briggs-Napier method, seems to be more easily grasped. As will be seen, this method presupposes no auxiliary theorems whatsoever, in fact it requires no knowledge beyond multiplication, the square root process and the law of exponents. Aside from showing how a table of logarithms may be constructed by the methods of elementary arithmetic, the work offers an excellent exercise for accuracy in numerical computation, admitting, as it does, of checks at every step. The writer's practice is to compute the first three numbers before the class, requiring the class to compute the remaining numbers in the list and to apply the checks as indicated.

The first step consists in computing the following successive square roots:

$$10^{\frac{1}{2}} = \sqrt{10} = 3.16228, \qquad (1)$$

$$10^{\frac{1}{4}} = \sqrt{10^{\frac{1}{2}}} = \sqrt{3.16228} = 1.77828, \qquad (2)$$

$$10^{\frac{1}{8}} = \sqrt{10^{\frac{1}{4}}} = \sqrt{1.77828} = 1.33352, \qquad (3)$$

$$10^{\frac{1}{16}} = \sqrt{10^{\frac{1}{8}}} = \sqrt{1.33352} = 1.15478. \qquad (4)$$

By definition the common logarithm of a number is the power to which 10 must be raised to produce that number, hence from

$10^{\frac{1}{16}} = 1.15478,$ $\qquad \log 1.1548^{*} = \frac{1}{16} = .0625;$

$10^{\frac{2}{16}} = 10^{\frac{1}{8}} = 1.33352,$ $\qquad \log 1.3335 = \frac{2}{16} = .1250;$

$10^{\frac{3}{16}} = 10^{\frac{2}{16}+\frac{1}{16}} = 10^{\frac{2}{16}} \cdot 10^{\frac{1}{16}} = 1.33352 \times 1.15478 = 1.53992,$

$\log 1.5399 = \frac{3}{16} = .1875;$

$10^{\frac{4}{16}} = 10^{\frac{3}{16}+\frac{1}{16}} = 10^{\frac{3}{16}} \cdot 10^{\frac{1}{16}} = 1.53992 \times 1.15478 = 1.77828,$

$\log 1.7783 = \frac{4}{16} = .2500;$

Check, $10^{\frac{4}{16}} = 10^{\frac{1}{4}} = 1.77828$ by (2).

$10^{\frac{5}{16}} = 10^{\frac{4}{16}+\frac{1}{16}} = 10^{\frac{4}{16}} \cdot 10^{\frac{1}{16}} = 1.77828 \times 1.15478 = 2.05352,$

$\log 2.0535 = \frac{5}{16} = .3125;$

*Only four decimal places are retained in order to secure accuracy in the last figure of all the numbers in the list.

$$10^{\frac{6}{16}} = 10^{\frac{5}{16}+\frac{1}{16}} = 10^{\frac{5}{16}} \cdot 10^{\frac{1}{16}} = 2.05352 \times 1.15478 = 2.37136,$$
$$\log 2.3714 = \tfrac{6}{16} = .3750;$$
$$10^{\frac{7}{16}} = 10^{\frac{6}{16}+\frac{1}{16}} = 10^{\frac{6}{16}} \cdot 10^{\frac{1}{16}} = 2.37136 \times 1.15478 = 2.73840,$$
$$\log 2.7384 = \tfrac{7}{16} = .4375;$$
$$10^{\frac{8}{16}} = 10^{\frac{7}{16}+\frac{1}{16}} = 10^{\frac{7}{16}} \cdot 10^{\frac{1}{16}} = 2.73840 \times 1.15478 = 3.16225,$$
$$\log 3.1623 = \tfrac{8}{16} = .5000;$$

Check, $10^{\frac{8}{16}} = 10^{\frac{1}{2}} = 3.16228$ by (1).

This computation is continued up to $10^{\frac{16}{16}}$.

The list of numbers which the student has thus computed corresponds to a set of mantissas differing by sixteenths distributed uniformly through the interval from 0 to 1; if unity is added to each of these mantissas the corresponding numbers must be multiplied by 10; if each mantissa is increased by 2, the corresponding number must be multiplied by 100; and so on in conformity to the law of characteristics.

It should now be pointed out that, similarly, with the aid of

$$10^{\frac{1}{32}} = \sqrt{10^{\frac{1}{16}}} = \sqrt{1.15478} = 1.07468,$$
$$10^{\frac{1}{64}} = \sqrt{10^{\frac{1}{32}}} = \sqrt{1.07468} = 1.03663, \text{ etc.},$$

longer lists of numbers could be computed whose mantissas differ by thirty-secondths, sixty-fourths, and so on. By continuing the process, the interval between successive mantissas can be made small at will. When the difference between successive mantissas has been made sufficiently small, the logarithm of any number, intermediate to two successive numbers in the list, may be found by interpolation. The numbers on the left if selected at equal intervals and arranged in a table together with their logarithms, form a table of common logarithms.

The process just described makes it possible to compute the number corresponding to any given logarithm. For any number can be expressed to any desired degree of accuracy as a sum of fractions taken from the series

$$\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}, \frac{1}{32}, \frac{1}{64}, \frac{1}{128}, \frac{1}{256}, \frac{1}{512}, \frac{1}{1024}, \text{ etc.}$$

Thus to find the number whose logarithm is $\pi = 3.14159$ we have

$$\pi = 3 + \frac{1}{8} + \frac{1}{64} + \frac{1}{1024}, \text{ nearly,}$$

hence

$$10^{\pi} = 10^{3+\frac{1}{8}+\frac{1}{64}+\frac{1}{1024}} = 10^{3} \cdot 10^{\frac{1}{8}} \cdot 10^{\frac{1}{64}} \cdot 10^{\frac{1}{1024}}$$
$$= 1000 \times 1.33352 \times 1.03663 \times 1.00225 = 1385.48,$$

that is the number whose logarithm is π is 1385.5.

PROBLEMS IN SECONDARY SCHOOL AGRICULTURE.

By D. O. Barto,

University of Illinois.

One of the newest educational propositions to which the people of this country have been asked to commit themselves is that the science and business of agriculture shall be taught in the public schools.

And the unanimity and readiness of assent with which this proposition has been met generally by people of every class has been rather startling to the proposers who were not anticipating so prompt an agreement with their views, but supposed it would be necessary to undertake a more or less strenuous campaign to convince or persuade the opposition.

It reminds me of an affair which recently took place in the street in front of my home. Two little fellows were struggling with an obstinate billy goat to induce him to go their way. Finally they attached a long rope to his horns and braced themselves for a long pull, a strong pull and a pull all together. However, no further effort was needed. Before they could straighten themselves the object of their persuasive measures was on their side and not much available breath was left for a time to continue the argument.

So the advocates of this new movement for agricultural education in the public schools are trying to recover their balance as they realize how suddenly there has been plumped down into their laps a stupendous job for which they are hardly prepared.

We all know, of course, that this interest in agriculture in our common schools is but one phase of the larger movement called industrial education which would extend the usefulness of these schools by including in their courses of instruction that training which fits for efficient service in all industrial occupations that are prominent in the school community. The importance which the work in agriculture holds in the new educational scheme is due chiefly to the wide area over which this occupation engages the interests of people and to the relations which agriculture sustains to so many other occupations and to all phases of business and social prosperity. It also has an added interest for us school men and women because it furnishes a new field in school work rich in so many forms of educative values, and there are many who believe they see growing

out of this effort to relate the education of the child to the real things of his home life ,possibilities of much promise for a work of great significance in the realm of social economics.

One of the serious questions that every educational institution must deal with is how to extend and diffuse among the people whom it is trying to serve the mass of valuable information which it is gathering and formulating and the results of carefully worked out investigations that would prove immensely helpful and profitable if the people for whom these things are done could be interested and trained so that they would use them. Only in proportion to the degree in which this side of the work is accomplished can a school or college feel that its mission is succeeding and justifying the cost of maintaining it.

It is with this thought that the University of Illinois is working upon the problem of public school agriculture, and the idea to which it has committed itself is that the proper channel for the extension and development of education in agriculture from the university to the people in the country is through the secondary schools of our educational system.

In some states a different policy has been pursued by attempting to introduce this work into the public schools first through the elementary grades. I think we are justified in saying that the results of all of these attempts have been on the whole disappointing. There are reasons for this, the principal ones being that the teachers in these schools are usually unprepared for the work and the pupils are not ready for it.

It must not be forgotten that agriculture is largely a science study. It requires some knowledge of the principles of many sciences, and the ability and interest to apply them intelligently. These conditions of scholarship can be expected only in pupils of a certain breadth and maturity of development and comprehension seldom found in the elementary grades.

A pupil can make little headway in the study of agriculture unless he knows something of physiography, geology, botany. zoölogy, physics and chemistry. It is not a question of whether he has studied these sciences before he takes up agriculture, whether he pursues them as separate subjects or learns them as he studies agriculture. The important thing is that some knowledge of these other subjects is indispensable to any serious and effective work in the study of agriculture, and this is a qualification that can hardly be expected to be attained in the elementary grades.

There is much valuable work that is scientific and agricultural that may be done—should be done—in the elementary grades when we have teachers prepared for it. But agriculture is an applied science. It has won its way only by demonstrating to the farmer that it could be made of practical service to him. As a school study its value and usefulness will largely depend upon the results that can be obtained from the application of principles of science, and this work will demand a sustained interest that young children cannot furnish.

As in the other sciences, the courses in agriculture in the college and in the high school should be made to overlap each other so that the union between the two shall be as close as possible.

In considering the problems of secondary school agriculture there are three factors whose interests are especially and directly concerned. These are the youth of our country, the schools and agriculture or country life.

You do not need to be told that no other three subjects could be named that are to-day everywhere commanding as great consideration from thoughtful people.

One of the most serious conditions existing in rural communities to-day is the open indifference manifested by young people for education, and toward all means of self improvement.

It is a pitiful sight—this waste of human life—throwing away without a thought of its value the most priceless inheritance that comes to man—the opportunities of his youth.

Yet none of us who is at all familiar with country life can have failed to notice how large a number of young people are apparently without any desire for a better education than they got in the lower grades of their country school, knowing nothing of the higher satisfactions that the habit and taste for good reading bring, and untrained and helpless in the ability to think or to express thoughts.

I am inclined to think that proportionately the number in this class who are wasting their lives and dwarfing their powers for usefulness so hopelessly is much larger in the country than in large cities.

The saloons and stores and blacksmith shops of small villages, and especially the forlorn railway stations in the country, are the usual haunts for these unfortunates, and one cannot help wondering as he looks at them what can be their chances in the race in life, with such a beginning!

These things appeal to me most keenly for they come close to my experiences. As I recall the playmates and school friends of my earliest years—boys bright and vigorous and full of promise, living in pleasant country homes—and count the number who have stranded by the way, who have lived aimlessly and without ambition, adding nothing to the progress and uplift of life in their communities and frequently helping to drag the general level of society lower—when I think by how narrow a chance I escaped from drifting off with these boy friends into the sluggish, purposeless existence where it was so easy to go, I am more eager to help in any movement that gives promise of lessening such deplorable wastes in human life.

It is only through education that the conditions that are unsatisfactory in country life to-day can be corrected or improved, and our problem is how can this education be secured?

Of course the schools ought to be the agencies for doing this work, but like all good instruments intended for service they are of value only in proportion as they are used. For years there has been in the country a growing disuse of the schools. There is no question but that this has been largely due to a growing doubt in the minds of both pupils and parents as to whether this education that the schools were offering them was something that they had any use for or would be of any real advantage to them if they got it, and so they have come to use the schools less and less. This has been unfortunate for the people and the schools, and both have suffered.

But these schools can, and it is their first duty to, restore the confidence of the people in their usefulness by making the schools serve the people's needs. And the people have the right to decide what their needs are. Heretofore the schools have been insisting that it rested with them to tell the people what sort of an education would be of most value to them.

Now the folks who live in the country and make their living on the farms and find their pleasures in the social life about their homes are learning to believe that the education that will be of greatest value to them is that which deals most directly with their own conditions of life and business and pleasures. This is what the city people some time ago asked for and are receiving. And this is one reason for urging that agriculture be taught in the high schools.

We know that the place where the schools most seriously lose

their hold upon their pupils is about the time of leaving the grades—the transition period from childhood to youth. Unless the high school has something to offer them in its courses of instruction different in character from the training under which they have grown restless—something which appeals to a new longing that is beginning to awaken within them to get into action and to be doing what seems to them real things, it is unable to hold them or pull them across, and so fails in its power to be of service to these young people at the very place where they are most in need of it.

Such a study as agriculture at this place in their lives meets this need. It furnishes work that is interesting and serious enough to appeal to the pupil's longing to do something, it connects with the affairs of the home, and it correlates with the more formal work in the text-book.

Another thing that the schools should be able to do for the young people at this period is to help them make a wise decision in regard to the occupations that they shall choose and prepare for. There can be no free choice in selecting one's lifework unless it can be done intelligently. Nothing affecting the conditions of country life and the welfare of country youth has been more deplored than the tendency of the young people to leave the farms and seek employment in the city. Unless this serious migration can be checked or compensated for by an equal outflow of as good material from the town, the outlook for agriculture and for the social and civic life of our country is not a pleasant thing to contemplate.

But the result of the education and training that are now given in our agricultural colleges is to give to the young people who study there a wholly new conception both of the opportunities which agriculture offers to those who choose it as compared with other vocations, and of the relative advantages and attractions which country life presents.

If this is the almost invariable result of the study of agriculture in the university where the students by daily contact are exposed to every attraction that other vocations can offer, it is reasonable to believe that agricultural instruction given in our secondary schools will be effective in giving our young people who are now in country homes a saner view of relative values in life and a deeper respect and fondness for the business of farming.

If this can be accomplished through the work of our public schools in teaching agriculture such work will need no further justification, for there is no graver question up before the people to-day than what is to be the character, the education and the ideals of the men and women who are to manage the great interests of agriculture and shape the conditions of living for the people who make their homes in the country.

Nor does this appeal for a change in the courses of study by the introduction of agriculture ask that our schools lower in any way their present standards of scholastic values. Rather is it the wish of the friends of agricultural education that this new study may develop side by side with those of longer standing in the schools and which have proved their right to their place by the service which they have rendered.

Such a relationship will be helpful to both and the relative positions that each shall hold and the time that shall be given to each in school curricula will easily adjust themselves according to the service that each can render to any particular student or set of students. This should be the only test required of any subject that seeks admission to a place in our public school courses of study.

In adding agriculture to the list of science studies in high school studies it is not expected that there will be more crowding or a lessening of the work done in the other sciences. The pupil who takes botany and agriculture, zoölogy and agriculture, chemistry and agriculture, for example, will in the same time that would be given to botany, zoölogy or chemistry alone get a better understanding of the principles of the science and will have acquired from the study something of far greater meaning and value to him than if there had been no agriculture with which to divide the time and work. In support of this claim is a statement recently made by Professor Hollister, high school visitor for the University of Illinois, concerning the science work which he saw being done in the John Swaney School, at McNabb, Putnam County, in this state.

This is a little school formed two years ago by the consolidation of three country, one-room schools. It was organized with a full four-years' high school course in which there are three and one-half years of agriculture. Said Professor Hollister in speaking of his visit to this school, "I have not seen such science work in a school before—such zest and earnestness in their work,

so full of meaning and purpose—and when I went into the classes in agriculture I found the explanation of it: Here was the place where they were applying what they got from their zoölogy and botany and physics; and if the agriculture was not good science work, I don't know where to find it."

A report of the same kind from another member of the faculty—himself a professor in the science department—was made to me a few days later, after he had seen the agriculture and science work in one of the good township high schools of this state, and he added: "If the high schools get to doing work of this character it will mean that we who teach in the university can, and must, push our courses higher up."

In another way the introduction of the study of agriculture into our high schools will prove an immense advantage to them by bringing these schools into closer touch with the people in their communities.

Every teacher understands what it means to the success and effectiveness of his work, if he has been able to secure the hearty support and coöperation of the people in his community, and to arouse an interest and sentiment in favor of the things which he is doing in the school.

For this reason the happiest results are following this introduction of agriculture into some of the high schools with which I am familiar.

Said one teacher some weeks after this work had been started in his school: "I can hardly believe that this is the same school where I used to teach. I have *all* the people as my pupils now, where I used to have only part of the children. Our school no longer stands off here isolated and lonely—no part of the life all around it. Now we are the very center of things." And what first brought about this change was using a Babcock milk tester as a part of the school work.

The third factor which was mentioned in considering this educational problem is the question of the practical application of this work in the high schools to the business of agriculture, and the conditions of country life. Can the schools in this way, without interfering with their legitimate function of educating children, be made to render a direct service to their communities that shall show in material and tangible results? May this work of the schools be made to help the farmer by making the business of agriculture more profitable for him? Can it be

put into actual use in helping to produce larger and better crops to breed finer stock, to give us more wholesome dairy products, and more of them, to build better roads, to have pleasanter homes, to care for and to secure more of the real satisfactions of life?

We believe that this is exactly what this work may be made to accomplish. It is what agricultural education in our state universities and colleges has done, and is doing everywhere in this country to-day. The value of their work in increasing the productiveness of the farms, improving the quality of farm products, bettering the methods of farming, and raising the standards of country living has been demonstrated so clearly that no one thinks of questioning it. But the number of people whom the universities and colleges can directly reach and care for must always be so limited that it is clearly evident that other agencies must be used to do this work. This falls within the province of college extension work. Why should not the high schools undertake this work and perform this service for the people? In this way they will prove their right to the name which was once given them, but was unfortunately forfeited—the people's colleges?

The ideal which we have set for ourselves in Illinois is that there shall be within the reach of every home good high school facilities, furnished and maintained free for all, as a part of our public school system, and that every one of these schools should be equipped and enabled to do that work which best meets the special needs of its people. And when the people more fully realize the meaning and importance of the words of ex-President Andrew S. Draper: "The wealth of Illinois is in her soils, and her strength lies in the intelligent development of them," it will not be necessary to preach that one of the greatest missions that our public schools have to perform in the service which they owe to the people is instruction in how to use without abusing this vast treasure-house of wealth—our soils—how to conserve, through intelligent methods, and not to waste through ignorance this immeasurable power locked up in these soils—it will be unnecessary because we shall be doing it.

FIELD PROBLEMS ON STREAM FISHES FOR SECONDARY CLASSES.

By T. L. Hankinson,

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A field study of the fish life of a region is a branch of biology that can under some circumstances be carried on with profit by classes in secondary schools. Some essential conditions for such work with pupils of these schools are: a teacher interested in fish study and having sufficient training and knowledge to conduct the work; a stream or other body of water near the school, or easily reached by trolley or some handy mode of transportation, where collecting and observation work can be done; and a school schedule that will permit a few hours of field work by classes once or twice a week; and a laboratory at the school where indoor exercises can be carried on in connection with the field work such as studies of fish in aquaria, identification exercises, and examinations of contents of fish stomachs.

The kind of fish habitat most generally accessible to those who wish to do field work with secondary school classes is probably the small stream, and this paper will be limited almost entirely to a consideration of problems regarding fish of our creeks and brooks. An ideal small stream for study is a permanent one, that is, one which does not dry up in the summer, and has clear water and a variety of environmental conditions for fish, brought about by a winding course, variable depth, and differing character of bottom and shore.

Important observations can be made at any time of the year when the water is not too high or roily, and when not frozen over with other than clear ice. A solid layer of transparent ice gives one an excellent opportunity to study stream fish in winter. The spring term is the best term for field studies with classes, for then nesting habits and migrations can be noted, and the subject is made especially attractive by the bright colors which the males of some species have only in spring, and then there is the interest lent by the pupils seeing the seasonal development of life in general during their consecutive visits to the stream.

As our field problems are chiefly ecological in nature, the fish habitats should be given attention, and before doing much else, it is necessary to get acquainted with our stream. One or more trips can be made for this purpose, and if possible, its

whole course examined. It is desirable to make a map of the stream, or the part of it to be studied. This can be done by the class as a whole, or parts of the work may be assigned to different students. Perhaps some correlation between biology and mathematics can be brought in here, by the teacher of the last-named subject giving instructions in map making. Important features of the physiography of the stream valley, and the principal plant formations and numbers showing depths of water can all be shown on the map. When the final maps are produced, copies of them can be made by means of a hektograph or other duplicator so that each pupil can have one or more copies. These will be found almost indispensable in the stream studies for many important facts can be recorded on them, and they will facilitate note keeping. The work done in preparing the maps will make the pupils well acquainted with the stream. It is desirable to give some attention to the whole stream system to which ours belongs. Published maps, like the topographic maps of the United States Geological Survey, when available, will be found very useful for this purpose. The water temperature ought to be taken and recorded at each visit, and the speed of the current noted. For comparative purposes the rough method of watching a small floating object go a certain distance and recording the time necessary for its journey can be used. In making the reconnaissance of the stream, it will be noted that all parts of it are not alike. Here is a deep hole; there is a riffle; in some places the bank is steep and bare of vegetation; in other parts it is low and grassy, overhanging the water. We thus find different environmental conditions for fish in different parts of its course. It is a good plan to classify these habitats and select types of them for special study. For example, there may be many deep pools in the course of the stream, but only one or two typical ones can be given particular attention, and but a few of the many areas of riffles need be studied intensively. Any one of these particular regions having similar environmental conditions for fish, selected for special study, is called a ***station***. Each station should be given a number to facilitate discussion, and this should be indicated on the map so that there can be no doubt on the part of any pupil as to what region is referred to by a particular station number. A careful description of each station ought to be made by each pupil or by certain ones assigned to study special stations. In these, all biological and physical conditions that might in any way influence the fish life

of a particular part of the stream should be described. This work will be much facilitated by making special maps of the region called stations and by taking photographs of them from different points of view.

The chief ways of getting facts about fish at a station are by collecting them for study and by observing them undisturbed in the stream. In regard to collecting: a certain amount of this will be necessary to acquaint pupils and teacher with the species of fish in the stream and to get facts concerning the exact nature of the food and to obtain data on some other problems. A small seine and one or more dip nets will be the most generally used pieces of apparatus for this work. Some of the fish collected should be brought alive to the laboratory and placed in aquaria. Valuable indoor exercises can be carried on with these, and by such study pupils will be aided in identifying fish when seen in the stream. Representatives of each species of fish and of any other organisms taken with them should be placed at once in 10% formalin, but for humane reasons they may first be anesthesized by putting them in water containing a little chloroform. By placing fish in formalin while still living, they will die with their fins expanded, which makes them much better for study. Pupils should make careful notes on all parts of the stream where collections are made. The specimens taken at a particular station should be labeled and kept separate from those taken at other stations during the trip. These collections can be brought to the laboratory and given to pupils to sort into what seem to them to be different species. Such work I find of high value in training the discriminating powers of students. The specimens of each species of fish taken at a particular station on a certain date should be put in a wide mouth bottle or other preserving jar by themselves and covered with about three per cent formalin as a permanent preserving fluid. Each jar should have a gummed label, giving besides the station and date, the name of the species. If this name cannot be obtained at the school, the specimens can be sent to some specialist for determination. Most of our stream fish can be identified by Jordan's Manual of Vertebrates. Pupils can easily do this work after a little preliminary study of fish morphology so that they will understand the structures referred to and the terms used in the keys and descriptions given in this book. Identification exercises on fish with Jordon's Manual have been a regular part of my zoölogy courses given to second year normal school stu-

dents during the last six years. The pupils have been almost invariably interested in the work, and it brings about a very noticeable improvement in their ability to make accurate and detailed observations. Not only will the specimens of fish from the stream furnish material for good laboratory work but they will form contributions to the school collection of local animal life.

The direct observation method of studying fish afield cannot be well carried on till the pupils have become acquainted with the appearances of at least the common fish as they are seen in the stream. This can be accomplished to a large extent by the laboratory and collecting methods already discussed. A good part of this work might be done prior to the spring term so that more time can then be used for field work. Since many fish, especially the larger ones, are shy, the class or individual observer should keep as far from the stream as convenient when making observations; and at all times be as inconspicuous as possible. Field glasses are almost as valuable in studying fish as they are in studying birds. A very successful method of seeing the normal actions of fish in a stream is to conceal oneself near a place where they are known to come forth, and wait for them to appear. By sitting almost motionless even in plain view, fish will after some time become accustomed to the sight of the person and give little heed to him. In riffles they can only be seen distinctly by means of a water glass. A simple water glass can be gotten by having a glass bottom put in an ordinary water bucket. By resting the bottom of this on a rough water surface and looking through it, objects can be clearly distinguished on the bottom where the stream is not too deep. Darters are easily found in this way, but of course the larger and shyer fish cannot be studied by this method.

There is a large number of problems concerning stream fish that can be studied by classes. How are the different species of fish in a stream related to each other? Some are closely associated and school together and take the same food and thus compete with each other in this respect. Some forms like pickerel, bass, and chubs feed upon other fish. There are several species that eat the eggs of other species and sometimes those of members of their own kind. Blunt-nosed minnows often flock in large numbers about nests of black-bass and sunfish to get the eggs if for any reason the fish guarding these nests are removed. It is well known that the peculiar little miller's thumb

of our more northern streams eats brook trout eggs. The phenomenon of schooling is an interesting one to study. Are schools composed of one or more species? Do fish of a particular size tend to school together? Is a school composed of the same individuals at different times? Does it lose and gain members as it moves about? There are other questions concerning schooling that will suggest themselves as observation work proceeds. The ways fish effect each other can be studied by the direct observation and the collecting methods. For a good example of the kind of information concerning the associations of species that can be obtained by studying collections, see Professor Forbes' paper on the Local Distribution of Certain Illinois Fishes, published as a bulletin of the Illinois Laboratory of Natural History in April, 1907.

The study of the relation of fish to other organisms will bring one in contact with several fields of biology. There are a number of animals that feed upon fish, and the ecological relation of any one of them to fish life will make an interesting and important subject for study. There are many organisms that are parasitic on fish, including protozoans, worms, and small crustaceans of a number of kinds, and some fungi, a good example of which is the water mold, Saprolegnia. The larvae or glochidia of fresh water mussels, as is well known, are parasites on fish. Some of these can be removed from a mussel and placed in the aquarium, and their methods of attaching themselves to fish can be noted. Whenever these are found on a specimen a record should be made of it. Fish also feed upon other organisms. To find out what these are, stomach examinations should be made, but some facts can be obtained by watching fish. Feeding habits are easily observed in many cases, and it is interesting to note the different ways our stream fish have of getting food. The suckers search the bottom with their long snouts; the top minnows glean the surface of the water; chubs and trout dash for insects that fall into the stream.

The distribution of fish in a stream is a perplexing subject. Daily and hourly fluctuations in numbers at a particular station are often observed. At night some stream fish are in very different kinds of places from those in which they reside in the daytime. Fish may be abundant in a stream for several seasons, and then they seem to leave it and perhaps return to it again after a year or so, and we can see no changes in con-

ditions for fish life during the time. These irregular movements are undoubtedly determined by laws about which we know little. What we want is data on this subject, and such data can be collected easily by secondary school classes. Careful notes should be made on all of the movements of fish, and efforts made to find causes for them. Pupils should attempt to discover the preferences that each species has in regard to habitat. What kind of environment does it select? The green sided darter, for example, will be found in shallow, swift water; the yellow catfish in deep holes usually with muddy bottoms. Classes might visit the stream at night to study distribution at that time. I have found an acetylene bicycle lamp excellent for illuminating the stream bottom. Very few fish seem to be afraid of this light. In regard to recording facts obtained about the distribution of fish, see an article in the *American Naturalist* for June, 1907, on A Graphic Method of Correlating Fish Environment and Distribution, by A. H. Wright.

A very attractive line of work is the study of colors of fish. Answers to such questions as these can be sought for: Is there any relation between the color of the fish and that of the bottom over which it is found? Are members of the same species of the same color wherever found? Can fish change their colors?

The study of the nesting habits of some of our stream fish should be an interesting line of work to follow with classes. Professor Reighard of the University of Michigan has obtained some facts concerning the breeding habits of our common creek chub that might easily be verified by secondary school pupils The fish makes a nest typically in the form of a ridge of clean gravel extending lengthwise of the stream. All of these nests found by myself have been located in shallow water at the lower ends of pools into which the streams were broken and just above riffles. The male builds and attends the nest. Small stones are picked up by this fish from near the downstream end of the ridge and added to it. In this way the nest increases in length, growing in the downstream direction. The male is very shy when at work, and appears to see objects at some distance from the stream. When disturbed, he will dart to the deepest part of the pool or under an overhanging bank, and will not reappear for many minutes after the source of his alarm has vanished. Spawning takes place at the lower end of the nest, and the eggs become mixed with the stones. In a handful of gravel picked up from the newer part of the nest, several eggs can often be found. Pupils

can bring these to the laboratory and hatch them, and rear the fish. I now have some chubs in an aquarium hatched from eggs collected in April, 1908. Professor Reighard has been successful in having classes study the habits of nesting chubs. Work with pupils can certainly be done by assigning individuals particular nests to study.

The blunt-nosed minnow which is so abundantly represented in our larger creeks and on the shoals of lakes has a nest that is very easily found. The eggs are placed on the flat under sides of stones on the bottom, close together in patches often composed of several hundred eggs. A male fish of dark color and with a patch of horn like pearl organs upon his snout guards each patch of eggs. This fish is very bold, and its actions in protecting the eggs are easily observed at close range. Dozens of these nests can be found on a single trip. Pupils can count the eggs, and in this way get some notion as to the struggle for existence in the species.

The habits of nesting sunfish are well known. In streams in early summer males can be seen guarding their nests, which are depressions, more or less circular in form, in the bottom soil of shallow water in some quiet part of the stream. These nesting fish seem very fearless, and often suffer themselves to be touched or handled. One of these nests or a colony of them will provide many problems especially concerning the behavior of the fish toward other objects.

In studying fish nests, certain data should always be sought and recorded: the depth of water at which the eggs are placed, the temperature of the water about the eggs, the size and appearance of the eggs and the approximate number of them in the nest, and the actions of the attending fish toward the eggs and creatures that seek to injure them. Fish-nesting is a subject that requires much patience for its investigation, but it will probably be found fascinating to most pupils, and any work that they do in this line can be stimulated by their knowing that there is a good chance for their adding new facts to our knowledge of fish, for little appears to be known about the breeding habits of the majority of our stream species. The paper on the Breeding Habits of the Rainbow Darter by Miss Reeves in the *Biological Bulletin* for December, 1907, and the one by Bertram G. Smith on Chrosomus erythogaster in the June, 1908, *Biological Bulletin* will give one ideas of what can be accomplished by a student of this subject.

A CONSIDERATION OF THE PRINCIPLES THAT SHOULD DETERMINE THE COURSES IN BIOLOGY IN THE SECONDARY SCHOOLS.*

I. The individuality of the teacher and of the members of his class, peculiarities of the local conditions—educational, biological, social, and industrial—make it undesirable and impossible that biological courses in all localities shall be uniform in all their details. There are, however, certain principles that should underlie the organization of all these courses.

II. The chief sources of divergences in the teaching of courses in biology arise from indefinite or varying notions concerning the following considerations:

1. Knowledge of the subjects to be taught.

2. The ends to be attained through courses in biology.

3. The materials and processes to be used in attaining the desired ends.

4. The relative importance of the various phases of the subjects included.

5. The point of departure and the methods to be used.

III. Concerning the topics listed under II, it is believed that:

1. The teacher of a biological subject should have knowledge of the subject matter greatly in excess of the amount actually to be taught in the secondary schools. He needs this for his own stimulation and for the stimulation of his pupils, for biological perspective, for unseen demands, for professional and scientific usefulness and self-respect.

2. The ends to be attained are suggested as follows:

A. General.

a. A purpose common to other subjects used in education is to secure to the pupils the best possible adjustment to the vital relations of their existence, at the same time retaining the maximum adjustability to changing relations. The development and proper discipline of the intellectual, social and ethical abilities is the leading general aim. Biological subjects are peculiarly fitted for this general educational purpose, since they constitute the study of life and of organic adaptation. They throw light on the meaning and methods of adaptation.

*At the meeting of the biology section of the C. A. S. & M. T. at St. Louis in 1907 a committee was appointed to prepare a statement of "biological creed." This report of that committee was presented at the 1908 meeting of the section in Chicago. The report was presented by Dr. T. W. Galloway, whose personal comments immediately follow the committee's report.

B. Special.

a. Since plants and animals offer objective, tangible, and in a measure understandable expression of life, the student may learn life processes in general, and derive an interpretation of his own place in nature. Knowing plants and animals is a proper part of good general intelligence—basal to a knowledge of self and self relations.

b. A more accurate, dependable, and efficient method of thinking is to be sought, since botany, zoölogy and physiology offer excellent opportunities for putting the students upon their own resources in solving problems. Although these subjects share with the physical sciences the experimental method, there is here the life factor with its introduction of variations of the problems to be presented. This universal variation in forms makes it true that in courses in biology the different members of a given species of plant or animal become so many different problems for as many different students to solve.

c. A first-hand knowledge of cause and effect should be derived from any good course in biological sciences. This knowledge, in addition to having great biological and general scientific value, has ethical values of great importance. One who has a wholesome working belief in the laws of cause and effect is likely to have such belief affect his conduct.

d. Much knowledge of practical use, as well as a culture-knowledge of the relations of biology and industrial life—forestry, agriculture, and manufactures based upon the use of plant and animal materials.

e. A lifelong interest and enjoyment of the constant observation of plant and animal life—not necessarily in continued courses of study, but in seeing and enjoying plants and animals from day to day.

3. The materials and processes to be used in attaining desired ends must be such:

A. As have appreciable significance to the stüdents.

This appreciable significance may relate to:

a. The satisfaction of a desire to know about the processes of plants and animals.

b. To a general knowledge of the practical uses of the material in hand.

c. To a general interpretation of life-relationships.

d. To aesthetic aspects of plants and animals.

e. To a desire to improve oneself in knowledge or in mental discipline.

B. They must have value for general knowledge by the public. As:

a. General culture value.

b. Appreciation and interest in the activities of plants and animals.

c. Understanding and appreciation of them (i. e., plants and animals) as a basis of arts and industries.

C. Materials must be such as can be arranged into a series of natural sequences so that the scientific method of problem solving may be best developed.

4. If the above principles are correct the question of the relative importance of morphology, physiology, ecology, etc., of plants and animals is easily answered by pointing out that the work is a synthetic study of the life of plants and animals of which the special study of structures and processes is merely a part. The study will not divide itself into morphology, physiology, etc., but will be made up of any parts of these aspects as may contribute to the development of the underlying principles of the course. It is understood that sometimes the problems will be essentially morphological, sometimes essentially ecological, but the student is to study the plant or animal and not the arbitrary division of the subject.

5. In considering the point of departure and methods to be used it must be recognized that:

A. To assure appreciable significance the first work must be related to the student's previous experience, not totally unrelated, as sometimes is true.

B. The work of nutrition and reproduction must be prominent; and will always serve as satisfactory points of departure in the study of most organisms. About these activities the teacher may readily cluster any studies he may wish to make of activities or structures or relations.

C. To develop proper methods of thinking the work must be based upon first-hand experience with the material; each assignment of work must be looked upon as a problem to be solved; sufficient time must be allowed for its solution and the solution may be rigorously insisted upon unless limiting factors prevent, in which case the limiting factors are to be located if possible; the solvable problems of the course are to be arranged

with such a relation to one another that they may stimulate continued effort and active, orderly thought.

D. The text-book, lecture, and illustrative work should follow and be based upon the student's experience with the materials. If this experience is good, it will serve as the concrete data by means of which adequately to interpret a large amount of text, lecture, and illustrative work, but these are not adequately understandable unless based upon meaningful first-hand experience in the field or laboratory.

Otis W. Caldwell, Chicago, Ill.
T. W. Galloway, Decatur, Ill.
H. W. Norris, Grinnell, Iowa.

In presenting this report for the committee, Mr. T. W. Galloway of Millikin University spoke essentially as follows:

"In the first place your committee considers that there is no one form of course which is necessarily best for all classes. The material is so abundant and the possible manner of treatment so varied and the personal element in both pupils and teacher so far from uniform, that uniform courses are not possible at present. Furthermore, we are of the opinion that such uniformity is undesirable, even if it were feasible. We believe that the richest asset of the department of biology is the fact that the subject has some of the plasticity of life itself; and that the very complexity which makes it necessary for the teacher to discriminate in the choice of his materials and methods gives it rare pedagogical value.

"The chief reason why the courses in biology differ in different schools are connected with the following things: the knowledge and preparation of the teacher; the general pedagogical attitude of the teacher in respect to the aims and purposes which he holds up before himself as worthy of gaining by the course; the conception of the best materials and processes to secure these ends; and special pedagogical views with respect to where emphasis should be put and the manner of beginning to make the appeal to the student.

"Some of these sources of divergence are to be met and overcome; others of them we hold to be legitimate and normal to progress in the development of the educational value of the subject.

"I assume that there is no difference among us as to the fact that the proper presentation of the subject in the secondary

school demands, in the preparation of every teacher of the subject, a series of courses in biology in the colleges and universities, which will enable the teacher really to select and adapt his course to the needs of the situation as he sees it. Otherwise the great range and richness of material which is a special advantage of the subject, as the real teacher sees it, becomes a positive source of discursiveness and disaster. Personally I am convinced that the teacher of biology needs, even more than the teacher of most subjects, a knowledge of the general subject of pedagogy. This need seems to me to grow out of the fact contained in our statement of the general purpose of biological teaching, found below.

"The common purpose of all education, in which biology shares, it seems to me is best expressed in terms of life itself. The prime purpose of life and education is adjustment, with the retention of the power of making new adjustment. One of the faults of our educative methods now is that if we succeed in securing the adjustment of the pupil to the seemingly great realities of his life we do it at the expense of his future adaptability. I believe that biology, because of its broad outlook on human interests both external and personal, not only clarifies the process of adaptation but also encourages the mind to retain its plasticity.

"At times we talk very flamboyantly about the formation of character. I know no way to do this except by adding bit by bit to those powers and attitudes of mind which will enable the individual to make the right response at the right time to the various stimuli which impinge upon him. It appears to me therefore that the subject of biology may have, in its study of individual and racial responses and of their results as determined by the laws of cause and effect, powerful ethical and moral contributions to the individual.

"Furthermore, your committee holds that all secondary courses in biology must have 'appreciable significance' to the students, and in a degree to the public at large. If the student does not recognize this at once, the first duty of the teacher is to make this significance perfectly clear.

"This means that the course, on last analysis, is to be determined beforehand, and step by step throughout its continuance, by the pupil and his needs and capabilities and interests and not by any logical conception of what constitutes a balanced course

in biology entertained by the teacher. This does not mean a disorderly and disconnected treatment, subject to the whim of the student; on the contrary we hold that much of the objection to the 'nature study' of the past is due to the fact that the natural sequences and their educative value have been neglected. It does mean, however, that we are primarily teaching boys and girls rather than a subject—even so good a subject as biology.

"Your committee does not hold that an intensive and one-sided view of one part of the realm of biology is as good for secondary education as a more balanced and broader view. It is vital that a false and distorted point of view shall not be allowed. There should be a synthesis of all those aspects of the subject important to its proper understanding; and yet this can be secured in harmony with the view that the pupil rather than the subject should be determinative of the course. In my opinion our section cannot too strongly insist that the biological material should be put before the student as presenting problems in whose solution he is interested. The day of elaborate outline is past. Likewise the time is past when we can claim it is enough to turn the students loose in the field and the laboratory and that they will necessarily get more from these than they can from books. The only outline which is tolerable, it seems to me, is one which the student helps to make, involving questions and problems for solution; questions which he recognizes as pertinent and interesting. There is no trouble in guiding this interest into any direction which the teacher regards as essential. Followed in this spirit there is no point at which education so nearly parallels the solution of the problems of life as in the biological laboratory.

"The reason why your committee thinks that a part at least of the experimental work should precede the text and lecture work on the same material is because of the solvent power of knowledge gained in a practical way upon the crystallized information of the books. It is not that we regard observed fact more highly than communicated fact; but that we deem that there are strong personal gains on the part of the student that justify the greater time necessary for observational results.

"Personally I wish that my adherence to the principles presented in the report may be interpreted in the light of the following propositions:

"1. I regard it essential that every student be allowed a normal and complete reaction, so far as possible, in respect to every series of observations and problems. If a student is allowed only to observe and to record his observations, and not to follow on through the processes which his own mind naturally suggests, we are not only failing to educate; we are actually robbing the pupil of his inalienable rights. It is taxation without representation, in respect to personality. It is infinitely better that the student be allowed to go on to the conclusion which his observations seem to allow, even though that conclusion be false in every detail, than that he should be allowed to feel that he has made his normal response to the great realities of life when he has observed and recorded the facts in an impeccable way. If his comparisons, definitions, inferences are wrong, it is relatively easy to put him after other observations which will enable him to correct them himself. The great point is that we shall encourage rather than discourage the natural tendency on the part of the pupil to go on from his observations to more vital things in the way of conclusions. It is not very wonderful that interest, even in the observation of nature, on the part of our children is lost if we allow them to lose interest in what lies beyond what can be directly observed.

"2. The teacher of biology is an experimental and comparative psychologist. The pupil is the subject of the experiment. The teacher is taking from the wealth of plant and animal phenomena certain materials and is using these to produce certain reactions on the part of the pupil. He is compelled to measure individual progress by the nature of the responses which the pupil makes to the various stimuli which he can bring to bear upon him. Each pupil is a different organism whose reactions must be watched and interpreted. The stimuli must be continually readjusted—not in consonance with a harmony preestablished by an association of biologists, but in respect to the peculiar response of the pupil whose personality is being developed. The pupil must be kept responsive, and not be allowed to become permanently quiescent in the presence of unsolved questions. It is through some such attitude on the part of the teacher that it may become possible to secure a mental adjustment to discovered facts without losing the attitude of alertness to the unknown which we have called adjustability."

TO SHOW EARTH CURVATURE.

By Robert M. Brown,

State Normal School, Worcester, Mass.

It is a revelation to many people that the curvature of the earth is of an appreciable amount on a lake one or two miles in length. When in 1870 Hampden wagered £500 that the convexity of the surface of any inland water body could not be shown, Alfred Russel Wallace disproved Hampden's contention by using as his basis a six-mile stretch of the old Bedford Canal. More recently, Mr. H. Y. Oldham has carried on similar experiments on the same level. This artificial water-way with its miles of straight-away surface has offered ideal conditions for the performance of this experiment. Such conditions however are not essential and we in this country have not experienced to any degree the wonder of this fact of the earth because, perhaps, a field of such peculiar merit is not at hand. In the north, at any rate, we are overrun with ponds and lakes and it is not difficult to adapt one's apparatus to a variety of situations. A pond one mile long is sufficient for the experiment and the only difficulty attendant on the performance disappears when an island dots the water surface near the center, or when the shore is convex. Three locations are required. When performing the experiment, at one station I set up on a chart stand a board about fifteen inches square. This board is divided vertically by covering the upper half with black paper and the lower half with white (Fig. 1). The horizontal line thus made is placed parallel to the water surface by suspending equal-lengthed plumb lines from the ends which just lap the water surface. The height of this line above the water is immaterial, but when the apparatus is set up the distance should be measured carefully and recorded (let the distance be represented

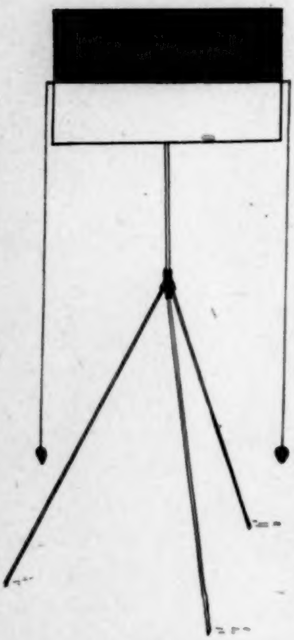

Fig 1.

by x). It is not necessary to use the same sort of apparatus as is here described. On the Bedford level, a sheet with a horizontal black band across it was fastened to the parapet of a bridge.

At the mid-station, a rod, one inch in diameter, painted white and mounted on another chart stand (Fig. 2) is erected with its axial line at the distance x above the water. The horizontal line of the board and the rod should be approximately parallel. In the Bedford Canal experiment a disc was used. It is not essential to have this mid-station exactly half-way between the outer locations.

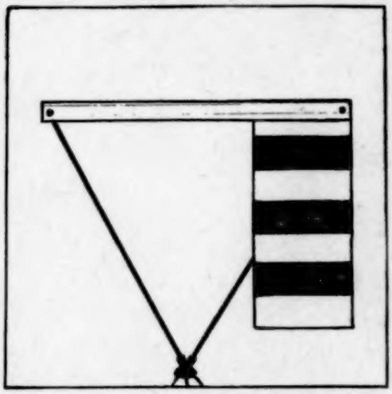

Fig. 2.

I have used a total distance of 8,875 feet, measured on the ice by chaining, and the mid-station is 4,222 feet from one end, and 4,653 from the other.

At the third station the telescope is erected with its axial point at the place of suspension at the given height, x, above the water surface. The horizontal line of the board, the axis of the rod and the middle of the telescope are now at the same height above the pond level. If the water surface is straight, the view through the telescope should project the rod against the horizontal line; if the water surface is concave the rod will appear below the line; if convex, the rod will appear above. The view through the telescope as seen at Lake Quinsigamond, Worcester, Massachusetts, with distances already noted, is sketched in Fig. 3. The experiment is one of great simplicity; no great amount of skill is required and the apparatus may be easily constructed. To me the experiment is a constant delight as it never fails to awaken enthusiasm even in persons who have figured out the actual amount of deviation to be expected in the given distance. It is an experiment that I can recommend to individuals for their own enjoyment and satisfaction or to teachers for their classes. If the distance be known, the deviation from the tangent may be determined by the following rule: Square the number representing the distance in miles, and two-thirds of that number is the number of feet of departure of the earth's surface from the horizontal plane. If on the other hand, the

drop or deviation from the tangent be known, the distance may be obtained by a reciprocal proposition, thus: Multiply the number representing the number of feet deviation by one and one-half and the square root of this product will be the distance in miles of the observation.

When the location of the rod is half way between the board and the telescope, by attaching a scale of inches such as is suspended from it in Figure 2, a calculation of the size of the

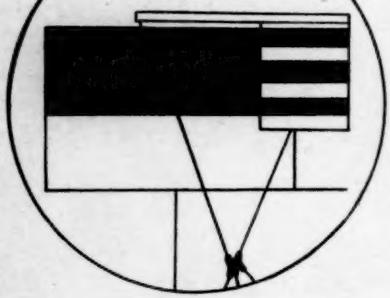

Fig. 3.

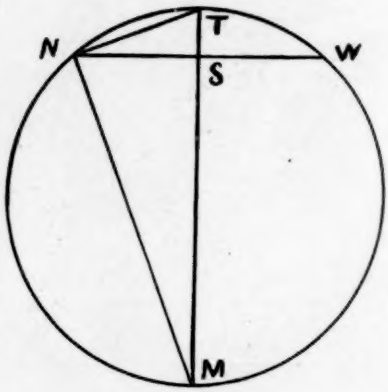

Fig. 4.

earth is possible. In the diagram, Fig. 4, N is the location of the telescope, T of the rod, W of the board and TM represents the diameter of the earth. The distance NS must be known and the drop TS may be read on the scale attached to the bar by means of the telescope. As the triangles TNS and NSM are similar, the proportion TS: NS: NS: SM is true. By the substitution of the known values and solving, the diameter of the earth is obtained.

A suggestion which I shall not make directly, but which can be read in what follows, may not be out of place. After I had for the first time reported* this experiment on earth curvature a New York engineer wrote me concerning it and at the end of his letter expressed the hope that I fare better than Wallace did. Wallace's experiment has already been mentioned. Hampden was a devotee of the flat earth school and had no intention of being otherwise. In settling the wager at the Bedford Canal, Wallace and Hampden each had a referee. Hampden's referee declared that the three points, telescope

*Nat. Geog. Mag. XVIII, 771. Dec. 1907.

disc, and black band, were in a straight line; Wallace's referee stated that the curvature was shown. Hampden refused to look through the telescope. An umpire chosen to settle the question awarded the £500 to Wallace. In his autobiography, Wallace states that the experiment cost him two law suits, four prosecutions for libel, the payments and the costs of settlements and between fifteen and twenty years of continued persecution. As late as 1885, Hampden published the statement that "no one but a degraded swindler has dared to make a fraudulent attempt to support the globular theory."† The flat earth school is extant. Its members are ready to enter into controversy with any person who allows himself to be caught in their net. My experience is amusing, and I retain as mementoes a number of letters from dwellers in this part of the United States protesting against my conclusions and attempting to point out to me the flaws in my experiment in statements which, if true, would be to my discredit. The Sunday press devoted considerable space to the explanations of these people and one paper announced that the "leader" of the flat earth school in this country had set up apparatus on Lake Quinsigamond and had proved by means of plate exposures that the surface of that lake was absolutely flat.

In the crude state magnesite is used for the manufacture of carbon-dioxide gas; calcined, it is used in the manufacture of paper from wood pulp and as a refractory material it is used in brick or plaster form for lining furnaces, covering steam pipes, as artificial lumber, as composite stone for lithographing, as an adulterant for paint, etc. Magnesium chloride is an excellent bleaching agent. The light carbonate or magnesia (alba levis) is used for medicinal and toilet purposes. The sulphate known as epsom salts is mainly used in warp sizing or weighting in cotton mills and lesser quantities are used for medicinal purposes. The hydrate is used in sugar manufacture.

It is possible that one reason why pre-cooling of the supply to air compressors is so seldom done is the dread of the "practical" man in charge that the air may be moistened. Of course moisture in the air is one of the chief troubles with which users of compressed air have to contend; but by proper arrangement of the cooling apparatus it should be possible to draw the air into the compressor not only cooler, but dryer than ordinary air. It will be remembered that the capacity of air to hold moisture rapidly falls off as its temperature is reduced. By subjecting the entering air to direct contact with cool water, the moisture will be condensed and caught by the water.

†"My Life," Alfred Russel Wallace, Vol. II, 381-393.

HOW MAY INSTRUCTION IN ELEMENTARY CHEMISTRY BE MADE MORE EFFICIENT?

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Our whole educational system is being very critically reviewed by many leading educators at the present time. It is severely criticised because the average student as he leaves our schools, of one type or another, is poorly fitted either to continue his studies in more advanced courses, or to meet the problems of practical life. Few of us would take the position that this criticism is not founded on fact. But we may disagree quite widely as to the cause of the discrepancy. I will venture to suggest that it is quite possible that the greatest mistake of our educational system is, that we rush our pupils into the consideration of problems, that because of their immaturity they are not capable of comprehending and that, in addition, we crowd our courses with a large amount of non-essential material. It is a serious mistake to suppose that the more ground the student covers the better trained he will be. Very frequently a superficial and inaccurate survey of a subject may be detrimental rather than helpful to the pupil, as it may unfit him for the logical consideration of another subject. Herbert Spencer is reported to have said, "If he read as much as other people he would know as little as they." If a subject is to prove of value to pupils they must be given time properly to digest and assimilate it. All too often the system requires the consideration of one subject after another in such rapid succession that no time is left for reflection. We are rushing our pupils through the grades and the high school and out into practical life or into college while they are yet young and immature. As a result the high school is criticised, because it does not give a practical education to the boy who is forced to leave school upon the completion of his secondary school course. On the other hand, the college and university are asking for better preparation on the part of the students that come to them. There seems to be a widespread impression that these two groups of students require quite a different sort of training. Consequently the teacher of chemistry is called upon to decide whether he shall make his course in chemistry theoretical or practical, whether he shall teach pure or applied chemistry.

As a matter of fact, it is not at all essential that the boy who will go behind the counter, or into the office, or into the shop shall receive training in elementary chemistry of a different type from that which the future physician, or chemist, or engineer receives. If the course in elementary chemistry is to accomplish much for either class of pupils it must combine the consideration of the practical with the theoretical; the acquisition of facts with their explanation; laboratory work with recitation work. In any event the prime object of the work should be, to teach the student to observe accurately, to think logically and to draw sound conclusions from observed phenomena. Our courses in chemistry should be planned with this object in view and we should not commit the error of thinking that the acquisition of useful facts should be the main object of a course which is planned with the utilitarian idea predominant. What is most needed for success in practical life is not large amount of knowledge, but the power to do things. Ability to arrive at accurate conclusions from given data, or, in other words, good judgment is the most essential factor for success in any sphere. It is as much needed by the practical man as by the college student, and vice versa. There is no subject which is better suited for developing the power to think than is chemistry, if it is properly taught. At the same time there is no subject that is more likely to be poorly taught than is chemistry. In the first place a very considerable amount of training in chemistry and general science is required to enable one to carry on work, even in an elementary course, in a wholly satisfactory manner. Not only must the successful teacher of chemistry be able to conduct recitation work well, but, what is much more difficult, he must also be able to so plan and conduct the laboratory work that the student shall thoroughly understand the significance of the experiments that he performs. Then, too, the subject matter of chemistry is so extensive in the vast array of facts and theoretical considerations which it presents that the student is quite likely to become confused unless care is used to present to him only so much of the science as he may be able properly to assimilate.

The trend of instruction in all classes of schools from the grades to the graduate school is toward a closer relation to the practical affairs of life. "Of what use is it?" is the criterion that is likely to be applied when this or that study is proposed for a place in the curricula of our schools. This tendency in

the educational system is resulting in the substitution of French and German for Latin and Greek, of geology for astronomy, of chemistry for Roman mythology. In short, there is a tendency to exalt pure intellectualism less and to demand that the intellectual development be directed in such a manner that it may be applied to meeting the needs of daily life. This changed viewpoint in education should result in the larger development or more complete retention of innate common sense while the student is receiving his mental training and in the better fitting of the youths who go through our schools for coping with the problems that are demanding solution all about them.

Chemistry is looked upon as a practical study and it is taking an increasingly important position in our courses of study. But notwithstanding the practical bearing of much of the subject matter of the science there is an ever increasing demand that instruction in elementary chemistry be made more practical and that less attention be paid to the preparation of the favored few for entrance to college. There is no doubt but that much may be gained by putting more emphasis upon that part of the subject matter of chemistry which has to do more directly with daily life and industry and less upon those subjects that have only a theoretical bearing. Fortunately this may be done without making the study of less value to the pupil who will continue his studies in an institution of higher learning. In fact if the material which is presented is chosen wisely all will profit alike by a knowledge of the practical applications of chemistry. On the other hand the study of chemistry may be made almost as useless as the study of Roman mythology if the theoretical abstractions of chemistry form the chief portion of the subject matter and especially if these theories are presented in such a manner that the student cannot distinguish between fact and theory. It is hardly going too far to assert that any work in chemistry that does not ultimately lend itself directly or indirectly to supplying some of the needs of mankind is useless.

Do not let it be understood, however, that I would minimize the consideration of the basal principles of chemistry. Just the contrary is true. To confine instruction to the facts of chemistry that have a direct practical bearing, excluding from consideration generalizations and theories, would be almost as fatal as to overemphasize chemical theory. We must bear in mind that the possession of an array of facts, no matter how useful

they may be, is of small consequence unless one understands the relation which they bear to the general subject which they concern. In short, facts are of value only as they enable us to think intelligently and plan wisely. It is important then for the boy that seeks a practical training that he should obtain a thorough understanding of the chemical laws, or generalizations of facts, and of the most important theories that are commonly employed in attempting to explain the facts with which he becomes familiar. Instruction in elementary chemistry will prove of practical value in just so far as it succeeds in enabling the student to solve the new problems that he shall meet after ne leaves school. To secure this result in the highest possible degree he must develop the power to apply generalizations to concrete cases with certainty. The ability to apply such principles as Boyle's Law, Charles' Law, specific heat, and heat of reaction to the solution of a practical problem is as likely to prove useful as in the knowledge that alcohol is manufactured from starch, or that brass is an alloy of zinc and copper, or that barium sulphate is an adulterant of white lead.

The close connection between the facts and phenomena that are studied in the class room and laboratory and actual practical experience is best emphasized by visits to manufacturing plants where chemical processes are employed. This feature of the work may prove useful not only in connecting school work with experiences of industrial life but also in keeping up on the part of the student a live interest in the science. As soon as the student realizes that he is learning to explain phenomena that he is to be continually meeting in daily life, and which he could not explain without a knowledge of chemistry, he is quite sure to regard the subject as well worthy of his careful consideration. Then, too, if he can be made to approach the subject in this way he is more likely to gain a working knowledge of a portion of the science, and less likely to look upon it as something to be learned, recited on, and then forgotten. The latter attitude is fatal to good work in any subject. But it is an attitude that is all too common in our schools. This was evidently the attitude of a freshman that I knew in a certain university. When asked in a written quiz to give the properties of nitrogen he wrote, "Nitrogen is a gas that occurs in the air in large quantities. It is one of the most poisonous substances known."

Class room work in elementary chemistry should consist very

largely of direct questions and answers. The teacher should conduct the recitation work in such a manner that the pupil shall be compelled to do independent and original thinking. The power to do this is the most valuable result that can come from chemical instruction. In order to secure this result in a high degree it is necessary that the student be in the objective rather than in the subjective state of mind. The opposite is true if the teacher does the larger share of the reciting. The teacher that is on the alert for opportunities of developing initiative in the student will succeed in getting the student to raise pertinent questions and then to answer them himself.

In this work the teacher should insist on definiteness of conception and clearness of expression. If the teacher would do his utmost toward the training of the pupil he will be compelled very frequently to turn aside from the teaching of chemistry for a few minutes during a recitation period and to give practical instruction in English, arithmetic, algebra or physics. A short time ago I asked a member of a freshman class in chemistry to determine the percentage of molecules of P_4, molecular weight 124, that would have to be dissociated into P_2, molecular weight 62, in order to yield an average molecular weight of 91. As he could not work the problem I thought that I would ascertain where the trouble lay, so I asked him to work the following problem: A load of pigs is made up of individuals weighing 62 and 124 lbs. each. The average weight is 91 lbs. What percentage of the pigs weigh 124 lbs. each? Out of a class of twenty, only one pupil was able within a half hour to solve the problem, although the members of the class were average students and were all graduates of representative high schools or academies. Of what possible use would it have been to try to get a solution to the problem in chemistry until the students had been familiarized with the arithmetical or algebraic method of solving such a problem? Of course, if the problem had been given to them in a class in arithmetic or algebra they might have solved it.

There is a strong tendency among pupils to regard the subject matter of each study as a thing by itself and most useful in enabling them to get ahead well in *that* subject. Then when an opportunity to apply the knowledge to the solution of a problem in some other line arises they are helpless. It will avail nothing for the teacher of chemistry to lament this fact and to

say that it is not his business to teach anything but chemistry. He must bridge the gap as well as he may, and impress upon the student the unity of truth and the interdependence of his knowledge of chemistry with that of English, arithmetic, history and the sciences, or he will fail as signally as his brother teachers, and the pupil will be unable to use his chemistry to advantage when he may come to the study of some other science for the mastery of which a usable knowledge of chemistry is essential.

Problem solving should take an important place in the recitation work in chemistry. There is no better way to develop independence of thought, originality, and logical reasoning in the class room than by the consideration of well selected problems. If the teacher is resourceful he will assign problems other than those of the stereotyped form so frequently found in text-books. Wherever it is possibie, problems should be selected that are based upon the experience of the student either in the laboratory or in daily life. In this way a vital connection may be formed between the laboratory and the class room work on the one hand, and between common experience and chemistry on the other.

The awakening of a keen interest on the part of the student is one of the things that the teacher should strive for. This may be furthered to a considerable extent by class room demonstrations. The teacher should refrain, however, from introducing too many experiments, the explanation of which the student is unable to grasp. No demonstration should be passed by until a majority of the students can see through the demonstration to the principle which underlies it. In general, the class will get much more benefit from this work if some member of it is called upon to explain the results than if the teacher takes the initiative. It is a fatal mistake to allow demonstrations to deteriorate into the mere making of a brilliant display. Brilliant demonstrations may be so conducted as to arouse only a momentary and artificial interest on the student's part.

The teacher is quite likely to err in assuming too much knowledge and experience on the part of the student. Faraday's lectures to children are worthy of the consideration of teachers of elementary chemistry. Everyone would do well to read his "Chemical History of a Candle." When the student begins the study of chemistry he faces a set of facts, the most of which are

new and unfamiliar to him. Those with which he is already somewhat familiar he has been accustomed to regard, in so far as he has thought about them at all, as the inexplicable secrets of nature. Consequently it is necessary to begin instruction with the simplest and most fundamental facts, and, building upon whatever information the student may possess, to proceed cautiously to the consideration of chemical laws and theories. Wherever possible the teacher should use familiar, rather than new, facts to illustrate principles. The concrete should always precede the abstract. The need of a theory should always be clearly manifest to the student before the theory is introduced. Theories should always be carefuly distinguished from facts and should be advanced as possible explanations of facts and phenomena. It is a mistake to begin the study of chemistry with the consideration of such subjects as Charles' Law, Boyle's Law and vapor density and to assign pupils problems involving these laws and having to do with gases with which the pupils are entirely unfamiliar. It is difficult to see how such a method of procedure can be considered scientific or how it can develop the scientific spirit which is so sadly lacking in much of our science work. Yet this very thing is met with in some of the texts recently published for secondary school classes in chemistry.

Never to introduce a law or theory unless the capacity of the pupil and the time available for the consideration of the topic are such as to make possible a thorough understanding of the same, is a good rule to follow. Thoroughness should be insisted upon even at the expense of omitting from the course some subjects that seem to be of prime importance. Accurate knowledge, limited though it may be, is much to be preferred to a hazy conception of a wide range of subjects.

Text-books are very valuable aids to teaching if they are well gotten up and they have an important place in the elementary course in chemistry. There is one place, however, where the text-book is quite out of order. That is in the teacher's hands during a recitation. To allow the student to conceive the notion that chemistry is confined to the text-book is as unwise as it is unnecessary. If the teacher desires to follow the text closely he should so familiarize himself with its contents that he can conduct a recitation without having the text before him. This may require considerable effort on the part of the teacher

at first, but this effort will be well repaid in increased efficiency.

If laboratory instruction is properly carried on it forms by far the most important part of the elementary course in chemistry. It gives the teacher an opportunity to become thoroughly acquainted with the characteristics of each student. It also affords an excellent opportunity for the close personal contact with the pupil which is so valuable in ascertaining just where the pupil is most deficient and how this deficiency may best be overcome. Liebig, who, as a teacher, stands in a class almost by himself, succeeded in turning out such chemists as Hofmann, Fresenius, Will, Fehling, Von Bibra, Gerhardt, Würtz, Frankland, Kekule and Volhard because of the personal laboratory instruction that he gave them. He spared no pains in instructing his pupils individually in the laboratory from the commencement of their course of study. To be at all satisfactory, laboratory instruction must consist in something more than assigning the student the work to be done and seeing to it that he hands in the results of the experiments written up neatly. A complete and neat laboratory notebook should be one result of the student's laboratory work. When I say that it should be a result of the laboratory work I would indicate that the results of experiments should be written up in the laboratory and not at home. Not only should this be true, but the results of each experiment should be written up as soon as the experiment is completed and not be left until the experiment has become confused with a number of others. In doing this, neatness in the notebook must be sacrificed to some extent. Laboratory notes should be written in simple and concise language and should embody only the essential features of the experiment together with the deductions which may logically be drawn from it. Wherever possible chemical reactions should be represented by equations. Care should be taken to teach the student to eliminate the unessential from consideration.

The student may be neat in his work and even perform all assigned experiments accurately and present a highly satisfactory notebook so far as the subject matter is concerned and yet fail to secure more than a small fraction of the benefits of a properly conducted laboratory course. This will be true if he performs the work mechanically. We have emphasized the fact that the most important result to be obtained from chemical instruction is the power to think and to deduce logical conclusions

from the results of experiment. To teach students to think is at once the most important and the hardest problem that the teacher faces. In the laboratory this can be accomplished only by individual instruction. This instruction should be given at the pupil's working desk and should take the conversational form. It should consist largely in making sure that the student understands and plans his work to good advantage and that he draws correct conclusions from his experiments. Above all things the instructor should refrain from telling the student how to carry out his experiments. Whenever the teacher can stimulate the student to originate the necessary means for accomplishing the desired results he should spare no pains in doing so. The instructor should show the pupil how to perform an experiment or perform it for him only when the student would consume an undue amount of time in working it out for himself I am well aware that this sort of instruction requires the highest type of teacher and that it is hard work. But it is the only sort of laboratory instruction that will bring satisfactory results. To accomplish this the teacher should devote the entire time of the laboratory period to the instruction of not more than twenty students. This necessitates the preparation of all laboratory materials either by an assistant or by the teacher before the beginning of the laboratory period. The number of laboratory exercises should be limited to the number that can be thoroughly mastered within the time at the student's disposal. It is much better for the student to perform a few experiments and understand them thoroughly, together with the theory connected with them, than for him to go through with a large number of experiments mechanically.

If I were asked to point out the factors that would result in the largest increase in the efficiency of instruction in elementary chemistry I would mention the following: a reduction in the number of topics considered; the elimination of much of modern chemical theory; a clear cut differentiation between fact and theory; and a much larger amount of personal instruction in the laboratory. In closing I cannot refrain from suggesting that it would be much wiser to omit the study of chemistry from a high school course altogether if an adequate laboratory equipment and a teacher who is well trained in chemistry and who can devote the requisite time to instruction in the subject are not available.

WERNER'S SOLUTION OF THE VALENCE PROBLEM.

By Jos. L. Coon,

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(*Continued from the February number.*)

The constitution of these association compounds is proved in the following manner: Consider for example $2NH_3.PtCl_4$ formed by the union of platinic chlorid and ammonia. The fact that the two ammonia groups may be replaced consecutively and in the same manner by the same or differing atoms or groups shows that they are entirely independent of each other. There remain then only three possible structures for the compound:

$$\underset{\text{I}}{\begin{matrix} Cl- \\ Cl- \end{matrix} Pt \begin{matrix} -Cl.NH_3 \\ -Cl.NH_3 \end{matrix}} \qquad \underset{\text{II}}{\begin{matrix} Cl- \\ Cl- \end{matrix} Pt \begin{matrix} -(NH_3)Cl \\ -(NH_3)Cl \end{matrix}} \qquad \underset{\text{III}}{\begin{matrix} Cl- \\ Cl- \\ Cl- \\ Cl- \end{matrix} Pt \begin{matrix} -NH_3 \\ -NH_3 \end{matrix}}$$

Either simultaneously or consecutively all four of the chlorin atoms may be removed from the molecule or replaced by other atoms, leaving the ammonia intact. This would be highly improbable if the ammonia were attached through the chlorine, and so number (I) cannot be the correct representation. If number (II) were correct the molecule would dissociate in solution in the same manner as ammonium chlorid; under the action of sulphuric acid it would give hydrochloric acid; also with silver nitrate a precipitate of silver chloride would be formed. Since none of these phenomena occur it is evident that the proposed formula is incorrect and that the chlorine atoms are all directly bound to the platinum atom. Number (III) is the only possible construction left and since by it only can the behavior of the substance be explained it must be the correct structural representation. In a similar manner the constitution formula of chloroplatinic acid is proved to be $Cl_4Pt—(ClH)_2$, and chloroplatinic hydrate $Cl_4Pt—[(\overline{OH})\overset{+}{H}]_2$.

From these examples it is obvious that two additional groups can add to the platinum atom of platinic chlorid without the formation of groups of the hydroxyl type, and that the idea of the valence theory that the formation of salts is conditioned by the formation of such groups is unnecessary and indeed, incorrect. Moreover, while all the compounds mentioned above are in fact closely related chemically, the old valence formulas were wholly

unable to show this likeness. The transformation from one to another called for essential structural changes. We see then that an alteration of the valence theory is necessary to explain the compounds of the higher orders.

Prof. Werner's deductions are that in compounds of the first order there remain certain amounts of unused affinities. As in carbon compounds with their double and triple bonds, so in nearly all primary compounds there must be a certain amount of unsaturated affinity on one or the other of the atoms. That is the affinity values are not exact multiples. While this affinity remainder is not sufficient in amount to take on another atom of the same element, at its individual affinity value it is still able to hold other groups. This is what happens in the cases of the higher compounds, though it is possible and even probable that in a very few cases a rearrangement of the molecule does take place after the addition. But even if this is true, it in no wise invalidates the theory that when to judge by the valence number, the binding power of certain atoms is exhausted, these atoms in most cases from the existence of remainders of affinity, still possess the ability to take part in the further building up of complex molecules, with the formation of perfectly definite atomic unions. It clearly follows that the structure formulas of compounds of the higher orders demand for most elements an increase in the binding power heretofore ascribed to them. The extension of the valence theory so necessitated is comparable with that resulting from the transition from the concept of fixed valence to that of varying valence. While, however, in the latter case the units were conceived of as being of the same kind, in Prof. Werner's theory the new forces are quite different in nature and action from the ordinary valences.

He divides the affinity forces into two classes making the first, the "principal valence," that which is ordinarily understood by the term valence. The second class, the "auxiliary valence," are those remainders of affinity whose existence must be postulated to explain the construction of higher order compounds. A convenient distinction between the two is to consider the principal valence as that power which unites simple or compound radicals that are capable of existence as separate ions, or whose chemical uniting power is equivalent to that of ionisable radicals. Auxiliary valences unite radicals that do not act as separate ions, nor are equivalent to such radicals. If one accepts the modern view

of the construction of ions and adds the postulate that on dissociation the chemical radical unites with an electron, then the principal valence becomes that whose saturation power is measured by equivalence with an electron; auxiliary valence becomes an affinity—activity then can unite two atom groups by atom-to-atom unions, but is not able to hold an electron.

It has been found that in general the auxiliary valences are weaker than the principal. That is, in all syntheses the operation goes in such a manner that all the principal valences are saturated while the auxiliary may or may not be, according to the conditions under which the experiment is performed. In any case the principal affinities saturate themselves first. This accords with the view that auxiliary valences are but remainders of affinity. It has also been discovered that in adding new groups the auxiliary valences more readily unite groups containing atoms of the same kind as those already present. Furthermore, on complete saturation the principal and auxiliary valences may mutually strengthen or weaken each other. An example of the strengthening action is cobaltic nitrite, an unstable compound, which becomes stable on adding three ammonia groups forming triammoniumcobalticnitrite. In some cases, indeed, it is hard to distinguish between the two kinds of valence, but such cases are comparatively rare.

The number of the auxiliary valences must be experimentally determined for each compound. Possibly with further research we may be able to discover types from which the auxiliary valence of any given compound may be predicted with a fair degree of certainty and exactness. And in this relation the question naturally arises as to why two or more auxiliary valences cannot coalesce to a principal valence. The question at present is left unanswered, but the observed fact is that apparently they never do. The hypothesis has been advanced that because of the spatial relations of the atoms the remainders of affinity are left on different portions of the atomic surface. And, since affinity is understood to be a force acting from the center outward equally in all directions, it would be contrary to all natural as well as mathematical laws for them to coalesce.

The sum of the maximum principal and auxiliary valences an atom shows in any possible compound has been called its co-ordination number. The value of this number must, of course, be determined experimentally. For an example take the case of

hydrogen, since this with its valence of one was at the basis of the old theory. In his recent experiments Prof. Werner has synthesized compounds in which he has fully demonstrated that this atom may and often does have a higher valence. The only possible construction for dimethylpyronhydrochlorid is $OC_7H_8O—HCl$. The compound resulting from the addition of pyrone to platinchlorohydrogen acid must be $[PtCl_4]H_2(C_5H_4O_2)_4$. Compounds of the type $XH(OR_2)_3$ have also been synthesized. In these compounds hydrogen necessarily has a valence of two, three and four respectively, that is, the sums of the principal and auxiliary valences are two, three, and four. Since it has been found impossible to produce compounds in which a larger number of groups or atoms is attached to the hydrogen, its co-ordination number is given as four. By the co-ordination number, be it understood, is meant the number of groups or atoms that may enter into the first sphere next to the central atom,—the numbers of the first sphere being those which do not enter into dissociating reactions and so show that they are directly bound to and in contact with the central atom. The number for hydrogen, carbon, nitrogen, boron, and perhaps a few other elements appears to be four; for all the other elements investigated, the results show it to be six. The work along this line is nearly completed as only a few elements remain uninvestigated. There are numerous apparent exceptions to the rule, but on close examination it is seen that they are only apparent. For example $(Mo\,Cy_8)K_4$ shows itself to be $Cy_4Mo.\,(2KCy)_2$. $SrCl_2.8NH_3$ probably is $Cl_2Sr.(2NH_3)_4$.

The auxiliary addition groups in these cases appear to be in themselves compound molecules held together by auxiliary valences,—a possibility which agrees fully with the theory, as will be better understood after a consideration of the next type of compounds.

Prof. Werner's second class of higher order compounds are the "Einlagerungsverbindungen", or the condensation and replacement compounds. The general law applying here is that the replaced atoms or radicals are freed from their direct union with the central atom, and in the addition product the replacing atoms or radicals are bound to the central atom by auxiliary valences. In consequence of the saturation of the co-ordination number of the central atom, the saturation of the freed atoms or valence can no longer take place in the first sphere, but must instead take up a position in the second sphere. As a simple type we may take the

ammonia compound with moniodid-methane. $CH_3I + NH_3$ $CH_3I.NH_3$. CH_3I is a non-dissociating molecule while $CH_3I.NH_3$ dissociates into (I) and ($CH_3.NH_3$) ions, clearly showing that ammonia has displaced iodine from direct union with carbon in the first sphere. The correct structure is then ($H_3C—NH_3$)I. The iodine is still bound to the carbon but the ammonia has taken its place in the first sphere and forced it to the second. Carbon here appears to have a valence of five, yet its co-ordination number remains four since but four atoms or groups are attached to it in the first sphere. As an example of the replacement action among the inorganic compounds we may consider the action of ammonia on the association-product, triammoniumcobalticnitrite.

$$[(NH_3)_3Co(NO_2)_3] + NH_3 \rightarrow [(NH_3)_4\ Co\ (NO_2)_2]NO_2$$
$$[(NH_3)_3Co(NO_2)_3] + 3NH_6 \rightarrow [(NH_3)_6Co](NO_2)_3$$

An important fact pointed out by the work on replacement compounds is that for the saturation of auxiliary valences it is not necessary, nor according to the facts, that the atoms themselves be bound directly to the central atom. Atomic groups may satisfy the remainders of affinity. The formation of hydrates is explained in this manner—the water molecules going in as a whole, viz.:

$$[(H_3N)_3Co(NO_3)_3] + 3H_2O \rightarrow [H_3N)_3Co(OH_2)_3](NO_3)_3$$

Frequently however the molecules go in as multiples of the formula H_2O. So the formula of $Mn.2Au.Cl_6.12H_2O$ is, according to this theory $[Mn(O_2H_4)_6](AuCl_6)_2$. That is, from the experiments recently made, it is evident that sometimes two or more molecules unite—probably bound among themselves by auxiliary valences—and collectively saturate one valence of the central atom. This explains the apparent exceptions mentioned in the consideration of the co-ordination number.

It is to be expected that the radicles and atoms taking up positions in the outer sphere may in themselves be compounds with their affinity forces largely satisfied and that they too may have atoms and compounds bound to them in their own outer sphere, and so on. As in organic compounds so here, no limit can be placed as to the molecular complexity of the possible compounds. The facts show this to be the case.

It is not necessary to enter more into the details of this class. All the rules and laws pointed out among the association compounds apply equally well here. The principles controlling the

actions of the compounds of these higher orders are identical with those governing the first order compounds. This affinity theory of Prof. Werner applies to all equally well and in the same manner.

If the theory is true we should expect to find in inorganic chemistry all the forms of isomerization known to organic. Prof. Werner and his associates set themselves to this task as the final proof of their theory. Their work has met with marked success; they have discovered all of the eight isomers and the method of changing one into another.

It would appear that the theory which is able to explain fully all the difficulties which the old theory encountered among the compounds of the first order, a theory which explains the actions among the higher order compounds, one by which we are able to predict unheard of and supposably impossible compounds and then point out the way in which they may be made—it would appear that such a theory is the correct one. Or if not absolutely correct, it at least would seem to be on the right track and so worthy of a careful study.

That Canadian gold coins will soon be an assured fact is made apparent by the visit to the Pacific slope of R. Pearson, chief assayer in the Ottawa mint, who has been traveling through the Kootenay and Boundary, with the object of investigating the gold resources on the lower part of the province. He will probably visit the Yukon in a few months.

Most hydraulic mines contain more or less fine gold which cannot be saved with the ordinary sluices, no matter how well the sluice is paved or how carefully it is manipulated. Under such circumstances, if conditions make it permissible, one or more undercurrents are very desirable. It is preferable to locate them near and below the lower end of the main sluice, for the reason that by placing them midway, fully 5 ft. of the available grade will be sacrificed in order to lead the water and tailings from the undercurrent back into the main sluice again.

About one-third of the lead of the world is produced in the United States. Spain and Germany combined produced about another third. Australasia and Mexico are also large lead producing countries. Of the 352,000 short tons produced in the United States in 1907, 125,000 were obtained from the Missouri-Kansas district, 111,000 from Idaho, 54,000 from Utah and 47,000 from Colorado. Germany is also a large producer of lead, having an output of one-half of that of the United States, and Australasia with an output one-third as large as that of the United States.

HOW THE PUBLIC WILL SOLVE OUR PROBLEMS OF SCIENCE TEACHING.

BY JOHN F. WOODHULL, PH.D.,

Professor of Physical Science, Columbia University.

In this prognostication I have thought it necessary to reinforce my views with the testimony of a score of witnesses. I beg leave therefore to act as the editor rather than the sole author of this paper. Its composite authorship will be found duly set forth in the various footnotes.

In this country we need not fear a revolution in matters of education both because democracies are proverbially conservative and because educational administration is now well organized. Changes are therefore sure to be a matter of development and growth and he who would work most effectively may prepare for what is before him by studying the history of the past and the trend of the present.

A very casual survey of history reveals the fact that education in this country has always been an exponent of the times.

When one considers the changes that have come over all educational institutions in the past generation, it is impossible to escape the conclusion that the public determines what shall be the nature of education. And this seems to be equally true whether we consider the so-called private or public institutions, and whether we consider elementary, high school or university education. All must be largely conventional and partake of the character of the times. This fact has been often recognized and commented upon both by those who regret it and by those who take satisfaction in it.

It should be noted that the college community is a part of the public and not apart from it.

I. THE PUBLIC WILL TAKE GREATER CONTROL OF EDUCATIONAL INSTITUTIONS AND THE NUMBER OF PUPILS WILL GREATLY INCREASE.

Fifty years ago there were only forty high schools in the United States. Now there are about twelve thousand. Ten years ago there were about half a million high school pupils and now there are about twice that number. The rate of increase in the number of pupils naturally is much greater than that of

buildings or of teachers. A similar state of affairs exists in the colleges, universities and technical schools. All this has occurred in spite of the attempts of some of the colleges to "put up the bars" and deny education to all but a relatively few. The methods of selecting those upon whom the fruits of education may fall are likely to be revised by the public who feel that the money spent upon education should make better citizens rather than a proletariat.

It has been shown that the academic methods do not select the most efficient candidates.

It has also been shown that of those who enter the high school two thirds drop out chiefly because the instruction is not adapted to their needs[1].

"The real difficulty lies in the lack of adaptation of the instruction in the high schools to the need and opportunities of the pupils." * * * "The instruction should be made as far as possible to serve the needs of the great mass of the pupils." * * * "The high school (as now administered) is essentially a 'select' school * * * the real and imperative needs of the many are sacrificed to the doubtful satisfaction of the needs of the few * * * what the whole system requires is the skillful provision for the real good of the greatest number."[2]

Dr. Edward J. Goodwin, president of Packer Institute and recently Assistant Commissioner of Education of the State of New York, as quoted in the New York *Times* for October 25. 1908, says: "We are gradually coming to recognize the injustice of organizing our high schools in the interests of the few alone. Our high schools contribute in New York State for example less than two per cent of the men who yearly enter the so-called 'unlearned' professions."

It is inevitable that all educational institutions will become much more crowded in the near future for the public is moving toward a greater control of the schools and colleges; and a still further increase of attendance upon our schools and colleges will forthwith compel us to make some modifications in our methods of instruction, so as to deal with larger numbers of pupils. For instance, it will make it difficult to seriously talk of "laboratory divisions limited to twelve."

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[1] Professor E. L. Thorndike, Columbia. The future of the College Entrance Board. Ed. Rev., May 1906. Also, The elimination of pupils from school. Bulletin of the Bureau of Inf.

[2] The New York *Times* in a recent editorial.

"The real voice of the voters who have lately so multiplied high schools has not yet been clearly heard, and their unformulated purpose has not yet been accomplished. * * * The evils of college dominance are now so great and manifest that they must be transient."[3]

"The people know what they mean by education after all really quite as accurately as we do, whose peculiar business it is to define the term."[4]

The conditions of our modern life are driving everyone to the study of science. Evening classes, extension classes, correspondence classes are multiplying. Books and periodicals give increasing space to scientific subjects. The development of machinery has made the study of physics not only a matter of interest but a necessity to all persons.

The automobile, the motor boat and the like are not only rivals of the schools in the teaching of physics but they are at the same time the most potent cause for the reform in that teaching.

From Sir Humphrey Davy, whose inaugural address at the Royal Institution sets forth the services of science to humanity and science as an agent in the improvement of society, through the long line of masters down to the present, there comes a complete and overwhelming condemnation of Cavendish exclusiveness in science.

"The subject matter of physics is far more closely connected than that of any other science with daily life * * * the things we need to know most are the physical things * * * there is no other science except chemistry which touches common life at so many points."[5]

II. THE PUBLIC WILL NO DOUBT REQUIRE THAT SCIENCE INSTRUCTION SHALL BE PRACTICAL, OR AS PROFESSOR BAILEY PUTS IT—APPLICABLE.

Unless it is applicable it can neither be scientific nor humanistic.

The high schools of the future will without doubt be more closely allied to schools of applied science than to those of pure science. There will be more of the study of processes than of principles; more of physiology than of anatomy; more of agri-

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[3] President G. Stanley Hall, Clark. Adolescence, Vol. 11, p. 515.

[4] State Supt. Henry C. Morrison, New Hampshire. Educational Review, October 1908 p. 247.

[5] Professor William F. Magie, Princeton. Boyle and Townley or Observation and Reflection. Proc. Physics Club of New York, January 29, 1904.

culture, nature study, natural philosophy as Faraday understood it, than of physics and chemistry, as the terms are now sometimes understood.

Faraday thought that physical science was a most appropriate study for children and mentioned *light* as a particularly good subject for that purpose. He who thinks that it requires a "heaven-sent gift" to study physics probably thinks of a very pure science."[6]

Professor William Conger Morgan of the University of California has an article in SCHOOL SCIENCE AND MATHEMATICS for November, 1908, on the "Relation of the Technical World to School Chemistry," in which he shows admirably how the high school course in chemistry might be enriched and he completely justifies the substitution of "practical" illustrations for the usual academic treatment when he says "the best reason for introducing experiments from the industrial world is to illustrate the general principles of chemistry."

This is not materializing or commercializing; it is the most effective way of teaching science for its own sake.

But let us put special emphasis upon the next division of our subject.

III. SCIENCE TEACHING WILL BE MORE HUMANIZED.

"Nothing is of real worth unless it can be directly connected with some result of conspicuous benefit to mankind.

"This attitude has profoundly influenced educational theory. This is a change of attitude of the world at large.

"Society wants the things of practical moment taught and it is the task of education to do it.

"Science has the confidence of the people before whose court it must justify itself. Science teaching has every natural advantage in its favor, including the keen interest of the pupil and no excuse will be accepted for its failure.

"Science teaching has its mission in general education. It may be taught so that it throws light on almost every phase of human interest.

"The lives of the great scientists are just as significant for education as the things which they stand for. The more students learn about personality the larger men they become."[7]

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[6] Professor Perkins, Trinity. The Present Status of Physics Teaching in Secondary Schools. Proc. Eastern Assn. of Physics Teachers. 1905.

[7] Dr. A. S. Dewing, Harvard. School Science. Oct. and Nov. 1908.

"It is gradually becoming clear that for purposes of teaching, science must be treated as a part of human experience. It must be so closely linked with the interests and problems of the daily life as to become part of it. It must be shown to have arisen for the purpose of meeting human needs and to have played a very important part in the development of our present social life."[8]

"The call to life, and to life in this world is the first and fundamental call of the scientific age, it is a call to sacrifice and to service and the call to service has been the deepening undertone of the call to humanism."[9]

IV. The Status of the High School Teacher Will be Greatly Improved and We May Hope that Great Teachers Will Arise as of Yore.

If we are to meet the needs of the public we must again have great teachers.

"The great teacher is the man of great personality, in whom nobility means more than attainments, and therefore the man whose personal touch upon the student is sure to be quickening and ennobling. He must know surely and clearly the subject he is teaching, but he must know even more profoundly and sympathetically the object he is teaching, namely, the other human beings, his pupils for whom he is guide and leader.

"The greatest students of this world have been formed one by one by great masters.

"Give me a good teacher, of noble nature, and I am comparatively indifferent to his or her scholarly attainments. The attainments will follow. Of what use for educating our boys and girls would it be to have the most gifted if that teacher is himself a small-natured, mean-natured, close-natured, little-natured soul?"[10]

"The educational process is not the mechanical impact of textbook or even of ideas upon the intellect, but the impact between living beings; and in the interaction of these vastly more is given and received than is ever formulated. What the teacher is expresses itself; and always the teacher's personality is the greatest educational influence."[11]

The high school age is the most important for education, and

[8] Professor C. R. Mann, Chicago. Ed. Rev. June 1907.
[9] Professor W. T. Sedgwick, Mass. Institute of Science of Teach. Science, Aug. 14, 1908
[10] Professor Andrew F. West, Princeton. Ed. Rev. Sept. 1908.
[11] Educational Review, October 1908, p. 295.

the public will there place its greatest teachers. They cannot be specialists for as intelligence increases in one direction ignorance becomes more dense in other directions. The specialist seldom measures up to the average intelligence of his own pupils.

The greatest teachers of the future like the great teachers of the past will teach not one but many sciences and these with reference to their applications.

"A generation ago * * * the work was usually in the hands of one of those admirable all-round pedagogues who were capable of teaching with equal facility every subject in the curriculum and it may be said in homage to their talent that the best of them taught every subject as well perhaps as some of the specialists of to-day teach the one subject to which all their time is given."[12]

> **"And we all praise famous men—**
> **Ancients of the College;**
> **For they taught us common sense—**
> **Tried to teach us common sense**
> **Truth and God's Own Common Sense**
> **Which is more than knowledge."[13]**

"A well rounded mind rather than the mind of one idea is the general purpose of teaching."[14]

Teaching is a "high and sacred calling" and we might expect it to react upon the personality of the teacher.

An Englishman writing of his visits to American schools says, "I have found teachers the most attractive class in the nation, because more than any other class, not excepting the clergy, they are free from sordid aims."[15]

We may expect that such teachers will maintain sympathetic relations with their pupils.

At present teachers appear to be divided into two camps with reference to their mode of treating the pupils. One party feels that there can be no education without coercion, the other feels that it is possible to win students to voluntary efforts which shall count for more. The first party accuses the second of using "kindergarten methods" and of entertaining and interesting pupils until they lose the capacity for work. Work, they claim, is their watchword, and play, they claim, is the watchword of the

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[12] Professor Nichols, Cornell. Proc. Eastern Association Physics Teachers. Dec. 1905.
[13] Stalky and Co., Kipling.
[14] Dr. Dewing. School Science, November 1908.
[15] Educational Review, October 1908, p. 295.

second party. But the second party has never agreed to this claim. On the other hand it says to the first party, you boast of work but you really administer sedatives. Your quantitative laboratory exercises and your mathematical treatment of physics is not hard, it is stupid. Its only justification is that it is the easiest thing for an overworked teacher to administer, particularly if he be a teacher who lacks the power to hold the attention of a class and therefore dreads qualitative experiments. Furthermore the second party claims that it secures a *compelling* interest in the subject which insures voluntary effort not only in school but out of school, and through life. These two parties have never been able to get together by argument and I take it that it is a hopeless case of lack of affinity. Unless I am greatly mistaken, these two parties in education would also be found to be two opposite sects in religion and for similar reasons. The first requisite of a great teacher is that he retain a vivid recollection of himself as a child, that he may be able to fully appreciate the pupil's point of view.

V. As the High School Teacher Increases in Dignity the Domination of the College Will Cease and the Evils of Uniformity Will Disappear.

"High school physics has problems all its own to which its representatives should address themselves with courage, resolution and above all with independence or else the present decadent tendencies due to college control will continue.

"College entrance requirements as now enforced are almost an unmitigated curse to the high schools, exploiting them against their normal interests and the purpose of the people who support them.

"The high school should be master not servant.

"Perhaps no institution in modern times needs inspection, visitation and scrutiny so much as the private endowed American colleges themselves." [16]

We can never have a truly educational treatment of any subject so long as it is studied solely with college entrance examinations in view.

In England and on the continent entrance examinations have been abolished on the ground that they are no test for power.

[16] President Hall, Adolescence, Vol. II, pp. 157, 510, 520 and 527.

"The function of secondary schools is distinct in itself and will one day establish its independent right when it has rid itself of the vicious term and still more vicious idea of college preparation."[17]

The high school teachers of this country have their subject matter and method of treatment minutely prescribed for them by those who understand neither the subject nor the pupils as well as they do.

Some persons unconscious that physics is a living subject, that every man, woman and child has his own physical world to study, varying with persons and with localities, demand that these high school pupils shall be fitted to the Procrustean bed.

They assert that physics is a quantitative subject; that it presents the greatest difficulty to all except those few who have special gifts. They say that this is predetermined in the nature of the subject. All this, however, has been explicitly denied by some of the greatest natural philosophers and the greatest educational philosophers. In the hands of great teachers few subjects are difficult; in the hands of some teachers all subjects are not only difficult but utterly incomprehensible.

"Any of the sciences can be made impressive if taught by a full mind which alone can elementarize,"[18] and the ability to simplify is one of the marks of true greatness.

"We must distinguish between the teaching function and the research function. It is our business as teachers to open the minds of the young to the facts of science. * * * Nature study is not a new subject, it is a new mode of teaching and is just as applicable to the college as to the common school."[19]

"The craze for uniformity more than any other one thing has led to the great success of our schools in the development of mediocrity."[20]

"Even more harmful than overcrowding is the oversystematizing which characterizes our present day methods. The tendency nearly everywhere is to reduce teaching to a routine and thus to deprive both teacher and pupil of the chance to do and think for themselves. A committee is appointed to draw up a syllabus and to outline the physics teaching for a whole state

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[17] F. Whitton, School Review, 1900, p. 261.

[18] Hall's Adolescence, Vol. II, p. 202.

[19] Professor L. H. Bailey, Cornell. Proc. N. Y. Science Teachers Association, Albany, 1907.

[20] Professor Stanley Coulter, Purdue University. Nature Study Review, January 1908.

or for the entire country. Every school equips itself to follow this program and every physics teacher goes through the prescribed course in the prescribed manner with section after section, day after day and year after year, until physics to him, instead of being the world-wide glorious science that it really is, is comprised within the scanty pages of the syllabus. Some spirits there are that refuse to be thus confined, but the tendency to uniformity levels down as well as up and the hilltops from which one may look out and view the true beauties of sciences are cut down in order that we may have a plain, easily traversed and easily cultivated." [21]

"The interests and needs of the pupils should be the determining factor in the arrangement of courses and the choice of methods.

"It follows that a high degree of uniformity in teaching physics is neither practicable nor desirable.

"Physics should be taught not as a preparation for college but as preparation for life." [22]

The Physics Club of New York, before whom Mr. Spaulding's paper was read on March 7, 1908, adopted the following recommendations:

"College entrance examinations as now conducted upon the broad and indefinite subject, physics, compel high school teachers to give their entire energies to cramming and drilling. In this matter experienced and efficient teachers have no advantage over inferior ones.

"It is manifest that a very definite and complete topical syllabus upon which examinations should be based would be one step toward the alleviation of this situation, but nevertheless such an instrument would constitute a galling yoke, forcing well equipped teachers to keep step with their inexperienced fellows.

"It seems probable that a very definite but incomplete syllabus by securing a certain amount of freedom in teaching, would enable the best teachers to do their best. Inexperienced teachers may be helped and guided by a Teachers' Manual, which should be much richer in suggestion than any syllabus can be.

Therefore, resolved that a uniform course in physics for all schools is both undesirable and unattainable. We recommend:

1. That syllabuses should deal with the barest outline of general

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[21] Professor E. L. Nichols, Cornell. Proc. Eastern Assn. Physics Teachers, Boston, 1905

[22] Mr. F. B. Spaulding, Boys' High School, Brooklyn. School Science, 1908, p. 674.

principles, leaving each teacher free to fill up the course according to his best judgment.

2. That examinations for College Entrance should be confined to the general principles specified in the syllabus and that a teacher's certificate should be accepted for other material—this might well take the form of a rather full statement of the work done."

It has been asserted that what the colleges want for preparation in science is very definite and perfectly well understood but this may be doubted when so many divergent opinions are expressed in print by college men.

In spite of the fact that the best high school teachers of to-day have become experts in their profession, the latest commission charged by the college entrance board to plan the work for high school physics contains not a single person actively engaged in teaching high school physics. A situation which would be impossible in any other country in the world now exists, temporarily I believe, in representative America.

VI. As Attendance upon the High School Classes in Science Increases, Individual Laboratory Work Will of Necessity Be Somewhat Curtailed and More Importance Will be Attached to the Lecture.

To begin with, the so-called inductive work will be eliminated from the laboratory.

High school pupils are sometimes taught to "test" and to "verify," in short, to learn things "first hand" when they have neither capacity for nor ground upon which to draw conclusions.

"I am an enemy of the inductive method in the school course. It is utterly absurd to expect an immature boy of fifteen or sixteen to perform that intellectual feat of generalization that is considered the most mature effort of the human mind. * * * It is supposing a mental endowment that only comes late in life to most of us and often never at all. * * * Bad as this method is in the hands of an experienced teacher it is confusion worse confounded when a novice attempts it."[23]

The laboratory at best is a very artificial means of supplying experiences upon which to build physical concepts. While it is useful and needful it cannot take the place of an appeal to life's experiences and the phenomena of nature. The charge that pupils may read about nature in books and not recognize her

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[23] Professor Perkins, Trinity. Proc. Eastern Association. Physics Teachers, December 1905, p. 25.

out of doors is quite as applicable to laboratory work. In physics it is too unreal; too much devoted to statics—too many things are presented which are never found outside of a laboratory and which are not parallel to or explanatory of anything found in ordinary human experience.

Professor Mann, Chicago, says that "for the general student college laboratory work is neither essential nor desirable."[24]

"Too much time is given to so-called laboratory work with elaborate and expensive apparatus. Too little attention is paid to simple and effective illustrations of physical phenomena and simple applications of fundamental principles to be found in every school room and its immediate environments."[25]

Professor W. S. Franklin, Lehigh, "My experience is most emphatically, that a student may measure a thing and know nothing at all about it, and I believe that the present high school courses in elementary physics in which quantitatve laboratory work is so strongly emphsized, are altogether bad." * * *

"I believe that the physical sciences should be taught in the secondary schools with reference to their practical applications. I cannot endure a so-called knowledge of elementary science which does not relate to some actual physical condition or thing, and I believe that the only physical things that are sufficiently prominent in a young man's mind to be brought into the field of his science study are the things which have been impressed upon him in everyday life. Say what you will, you must do one of two things to be able to teach physics in any school; either you must create an actual world of the unusual phenomena of nature by purchasing an elaborate and expensive equipment of scientific apparatus or you must make use of the boy's everyday world of actual conditions and things."[26]

The public has expended lavishly for laboratory equipment in physics, doubtless in the expectation that their children will be better instructed thereby to cope with the new conditions of modern lfe. There is no department of education which the people have more at heart and there are abundant signs that they will not long permit their purposes to be thwarted.

Education is not wholly a process of training. It is in considerable measure a matter of acquiring the mass of information whch it is conventional to have at any particular age.

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[24] Education, December 1906.

[25] Mr. J. W. MacDonald, Agent Massachusetts State Board, Report for 1907.

[26] Professor W. S. Franklin, Lehigh. Proc. 12th Annual Meeting N. Y. State Science Teachers' Association, Albany, 1907.

The lecture is the only means by which we may bring in all the good things that we feel moved to introduce. The great teachers of the future will be able to instruct large classes by "talks, which is the method of the real teacher."

This is to-day the method of the German teachers who are notoriously the best teachers in the world.

Large portions of science should be merely touched upon; made understandable for a brief moment and then forgotten, not even retained for recitation, much less for examination.

"Curiosity and interest are generally the first outcrop of intellectual ability. Youth is normally greedy for knowledge and that, not in one but in many directions.

"Never is the power to appreciate so far ahead of the power to express and never does understanding so outstrip ability to explain. Overaccuracy is atrophy. Mental acquisition sinks too deep to be reproduced by examination. With pedagogic tact we can teach about everything we know that is really worth knowing, but if we amplify and morselize instead of giving great wholes—if we wait before each methodic step till the pupil has reproduced all the last we starve and retard the soul.

"The nature of youth demands that science should be taught in a large all-comprehensive way. We must have an introduction to science that touches rather lightly on nearly all the great hypotheses over the whole field.

"The boy in his teens needs great wholes, facts in profusion, but few formulæ. He has a native gravity toward those frontier questions where even the great masters know as little as he.

"The college should stand for extensive more than for intensive study.

"It should stand with doors hospitably open to those who have time to pause for it on the road to a profession, or to spend a period of culture and acquire an avocation before entering a career. It should let teaching have its perfect work.

"The teacher should forage widely and incessantly, and bring everything within reach in his field to his class. The lecture method should be made the most of, being conversational and designed to provoke reactions. He should teach every topic broadly and comprehensively, and instead of disparaging mere information, it should ooze from his every pore.

"Every great expert should feel it his duty to put the best that is in him in a form most interesting and profitable to a cultured lay audience."[17]

[17] Hall's Adolescence, Vol. II, pp. 85, 453, 151, 156, 528, 548.

The lecture room is the place for presenting the history of science and the biography of scientists; the story of inventions and how they have transformed society; the rise and development of modern scientific theories, e. g., the slow progress of thought concerning combustion through the phlogistic up to the oxidation theory; the linking of the history of science with general history showing how the evolution of science was both helped and handicapped; the contributions of science to our comfort, our health and our general happiness.

Mr. B. M. Jaquish of Erasmus Hall High School, Brooklyn, N. Y., in an unpublished paper has very effectively shown that countless references in all our literature require for their interpretation a general knowledge of science and this is rapidly becoming a *sine qua non* for current literature.

The lecture should show the application of science in the occupations of the particular community in which the school happens to be located.

Hence no syllabus can be made to fit the whole country. If the school is in a large city and is located in one of our most modernly equipped buildings the lecture in physics will often be devoted to an explanation of that equipment which will be found to illustrate every chapter in physics far better than any laboratory can.

VII. We May Undertake to Frame a Platform for Future Science Teaching as Follows:

1. Science for high schools consists of a well organized mass of useful information.

2. In order that the amount of information may be considerable it is given for the most part "second hand."

3. The three means for giving this information, stating the more important first, are: (a) Illustrated lectures. (b) Study of text-book with recitations, and reading many references in books and magazines with written and oral reports. (c) Laboratory work—a small portion of which consists of exact measurements.

4. This mass of useful information being acquired at the hand of a competent teacher involves discipline and training.

5. While the science teacher has a peculiar part to perform in the processes of education which the teacher of no other subject can do so well, his task is not absolutely unique and the

methods of instruction which are best in the treatment of other subjects are for the most part best for science.

6. A quantitative treatment with whole numbers, so to speak, runs through much of the instruction in lectures, recitations and laboratory work—giving concreteness and therefore interest to the subject—but this is only incidental and of minor importance.

7. Science is not presented as a catalogue of principles, but rather as history, biography and the evolution of changing ideas. The topics for study are phenomena rather than laws, and principles are presented only for the purpose of explaining some definite problems in life.

8. Since all this applies equally to all general or first courses whether given in high schools or colleges, it follows that college admission tests are the same as high school graduation tests.[23]

The foregoing paper was presented before the Science Conference of the Wisconsin State Teachers' Association at its meeting in Milwaukee on November 12. After the reading of the paper there was a spirited discussion of it, resulting in the appointment of a committee of five to draw up resolutions expressing the sentiment of the meeting. The following are the resolutions, which were unanimously passed by the conference the next day:

WHEREAS: The present methods of teaching physics in secondary schools do not yield as satisfactory results as we desire to get; and,

WHEREAS: We believe this to be due to the fact that far too great emphasis is now placed on accurate quantitative work; and,

WHEREAS: This overemphasis of the importance of quantitative work is due to the fact that some colleges take the position that physics is by nature a quantitative science, that it is the only such subject in the high school curriculum, and that it must therefore be so taught, irrespective of the needs and abilities of the pupils; and

WHEREAS: We believe that physics for high schools should consist of a study of the processes and principles of phenomena of the daily life of the student; therefore be it

RESOLVED: That we, members of the Science Conference of the Wisconsin State Teachers' Association, in convention assembled, do hereby agree to change the methods of teaching physics by abandoning as far as may be found desirable the exact quantitative work, and by substituting therefor a more living treatment of the subject based on the daily experiences of the pupils.

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[23] I have discussed rather fully this platform in four papers already published as follows: 1. "The Enrichment of the High School Course in Physics." Proc. Eastern Assn. Physics Teachers, Boston, November 5, 1904. 2. "Modern Trend of Physics and Chemistry Teaching." Educational Review, March 1906. 3. "The Intensive Method in Chemistry." School Science, Vol. VI, p. 585. 4. "Science for Culture." School Review, Vol. XV, p. 123.

THE PROBLEMS OF SCIENCE TEACHING.*

By President Ira Remsen.

Johns Hopkins University.

A battle that has long been waging has been won—the battle for the recognition of science in the courses of study in schools and colleges. I remember well my first experience as a teacher of chemistry. I had accepted a position in one of the small New England colleges without having examined the equipment. When I arrived in the fall ready to begin work, I found that the institution did not possess a laboratory. I at once applied to the president for one, and he replied: "What for? I have taught chemistry, and I thought successfully, without a laboratory; and if I could do it, I think you can. This is not a technical school; what the students want is the broad general principles of chemistry." So I tried to teach without a laboratory. I was wholly unsuccessful; the students learned nothing—in fact, some of them told me so in later years. The experience was, however, very useful to me. I learned a great deal from it.

Now science is recognized; we have laboratories everywhere and laboratory training is regarded as indispensable. It is therefore fitting to ask: What are we doing with our facilities? What results are we obtaining? When the battle was on, men lost their heads—men must lose their heads in order to fight. We thought that if only we could get laboratories, the problems of education would be solved. Is this true?

Pedagogical problems are hard to solve—it is very difficult to get sound conclusions. How can we tell whether the scientific training is more effective than that of the older type? This is a problem that cannot be solved by sitting down and thinking about it; it can be solved only by research and experiment. I do not myself know whether scientific training as now conducted is producing the results hoped for. Yet I am convinced that scientific training, when properly conducted, may be of the greatest value as an educational force. This is quite a different thing from saying that that particular thing now known as science training is of great value. It all depends upon how it is done.

Personally I have been guilty of all the sins possible for a teacher of science. I have been experimenting to find out how

*Read before the joint session of the American Federation of the Mathematical and Physical Sciences and Section L of the American Association for the Advancement of Science.

to teach chemistry; and it is the most difficult experiment I have ever tried. My own experience in school was very instructive to me, for my own education was most unsatisfactory—in fact, I never was educated. My first experience with chemistry was gained in a course of lectures one hour a week by one of the greatest chemists of this country, Professor Wolcott Gibbs. Yet from this course I learned nothing. My second experience came when I had taken up the study of medicine. The teacher knew little chemistry, and I was asked to assist him in preparing the experiments for his lectures. He had a large practice, and left me alone to prepare experiments that I had never seen. I am almost ashamed to confess what happened that year—there were explosions and fires and bungling beyond words. I had little or no guidance.

In my first course the instruction had been "theoretical;" in the second I had the "practical" galore. I therefore thought I was an experienced chemist and could go on and take an advanced course. It was a sad awakening when I found that I knew practically nothing of the subject.

But to return to our theme: Are we doing the best that is possible with what we now have? Do the results obtained justify the equipment and time devoted to scientific study? I am not qualified to answer these questions for the schools; but speaking for the colleges, I may say that in my opinion the results are frequently quite unsatisfactory. The reason is that we have not yet learned how to deal with the subject. It is not hard to teach chemists chemistry, but it is very hard to teach beginners something that is worth while about chemistry in one year. What can be expected of a one-year course? Have you ever seen students who obtained an intelligent knowledge of any subject in one year? We cannot expect anything of great value in that limited time. If getting knowledge of a subject is the object, we cannot expect much of even the best teachers. But the important point is: Are we doing the best we can under the circumstances?

There are two points in which it seems to me we might do better—two defects that might be remedied. One defect is that the student is not subject to enough supervision in his laboratory work. He is very much in the condition in which I found myself when turned loose in the laboratory to prepare experiments I had never seen. He is turned loose with a book, and

then left alone. This is not conducive to scientific work. School authorities do not realize the need of enough teachers for the sciences. The head teacher generally expounds the subject and leaves the laboratory work to inexperienced assistants. It is too much work for the professor to have to spend four or five hours a day in the laboratory with the students. If we could get teachers with deep interest in their subject and in their students, it would solve the problem; but in science, as in other subjects, we are not going to find these often. Unless we can find out how to produce good teachers, we shall fail to get the best results.

The second important defect in the present teaching of chemistry in college is the absence of repetition. There are too many fleeting impressions. There is a little about a great number of things, as oxygen, hydrogen, chlorine, nitrogen, phosphorus—each being treated as something new with no reminders. In language there is much repetition; each new lesson continually connects with the past work. Yet it is only by repetition that we learn. We do not learn a game by being told how to play and then trying it once. Repetition is largely lacking in science teaching. We cover too much ground. The student gets only a veneer. Knowledge of this sort is not of much use, and the drill given by such study is not effective. We must introduce into science teaching the drill element that comes only from repetition of the sort that is characteristic of languages and mathematics.

Chemistry has one kind of work involving repetition of the right sort, namely, qualitative analysis. This field offers good educational possibilities, but the work is in great danger of becoming mechanical. The student is prone to go through the motions with his mind on his book, to guess at the results, to report, watching the reaction of the teacher closely, and to get credit. In order to introduce this element of repetition, quantitative work has been introduced to save the situation. Some quantitative work is desirable. It makes it possible to keep a student at one experiment till he has obtained good results. Such work is monotonous, though it has the advantage of not requiring the student to cover too much ground.

The remedy for these two important defects is unfortunately unattainable at present. We must get good teachers. Much is being done in the way of training teachers, and much that is good is coming from this work. Yet we must not forget that

good teachers are not easily made. It is harder to train a teacher to conduct laboratory work efficiently than to train one to teach mathematics or a language. In science the laboratory presents a new problem, and serious errors have occurred and are occurring. Yet, in spite of this, great progress is being made, and there is little doubt that in the end scientific training will fully justify itself in the schools and colleges.

In closing let me again specifically state that I do not consider myself competent to speak of science training in the secondary schools; all that I have been saying applies, so far as my own definite knowledge goes, only to the colleges.

A RETROSPECT AND A VISION.*

By William E. Stark,

Ethical Culture School, New York City.

One can always see a thing in truer proportion by viewing it from a distance. In the last three years since I gave up teaching physics, my confidence in the validity of some of the principles to which I had clung for years has gradually weakened and the number of things which I think that I would do differently, if I were to teach the subject again, has gradually increased. I have no intention of making a sweeping criticism of present conditions and I do not presume to be qualified to judge your work. I propose merely to speak of the misgivings which have come to me about my own teaching and of an occasional vision of something far better which has appeared within range in moments of optimism. I hope that my experience may touch yours closely enough to make my confessions and my suggestions of interest. I shall be particularly interested to know how far you men who are teaching physics regularly will agree with my notions.

As a schoolboy, I had the Harvard course in physics soon after it was devised, and in all the years of my teaching of the subject, I have had college preparatory pupils. It is not surprising, therefore, that the forty experiments should have filled a large place in my conception of the proper course for high school pupils. I was always rather more fortunate than the average teacher of physics, in regard to time allotment, and was,

*Paper read before Physics Club of New York, March 7, 1908.

therefore, not greatly impressed by the complaints of some of my friends in the profession of the difficulty of meeting the requirements.

I have always enjoyed exact measurement. The careful determination of physical constants and the consideration of percentage of error have always appealed to me. The quantitative experiments naturally seemed especially worth while, and I used to value highly some of the experiments which recent practice has tended to disparage. I stood for much individual laboratory work, for the mathematical statement of physical laws, and for the solution of problems based on any relation which would lend itself to mathematical statement, as an essential test of the understanding of the relation.

The dictum of the Committee of Ten that the same course should be taken by all pupils I accepted on authority. It seemed reasonable enough at the time that what is good preparation for life is good preparation for college. The college preparatory course in physics seemed adequate as a basis for such preparation.

I welcomed the tendency to make the class-room work touch life and used illustrations especially from engineering practice freely. Time permitted one or two excursions to industrial plants, telephone exchanges and the like, though not as many as I should have liked to make. I approved of the suggestion that some use be made of the history of physics but never found time to carry it out in practice.

The boys, as a rule, and a few of the girls were thoroughly interested in the work and did it well. In most classes the majority of the girls had no very strong interest and some found it next to impossible to get any real grasp of the subject as presented, although most of them succeeded by painful effort in remembering enough to pass the examinations, both at school and at college.

As I think of my experience with these classes, I am convinced that the work as given was excellent training *for some of the pupils* but that others gained comparatively little of permanent value. Many of the pupils did catch an enthusiasm for exactness of work. For them such work was a real training which gave permanent results in their attitude toward experiment and measurement.

For some pupils, too, the mathematical treatment of the subject is a delight. I am not in sympathy with the recent attempt

to cut out practically all mathematics from the subject. One of the most important conceptions to be given the student is, in my opinion, that of the existence of order, law, exactness of relation, in the universe. The student ought to be given some sense of this exactness of relationship, and some notion of the tremendous part which a knowledge of mathematics has played and is playing to-day in the development and application of science. Now, to deny the student with some taste for mathematics this view in the form in which he can grasp it most clearly and with the greatest enjoyment is, to say the least, neglecting an opportunity. For some of my pupils, then, the mathematical treatment and the quantitative experiment were of distinctly more value, so it seems to me, than a qualitative treatment would have been. For other pupils, however, and especially for most of the girls, a course in which less exclusive emphasis was laid on the quantitative aspect would, I now think, have been more effective.

This raises the question of the validity of the view that there is one best course for high school pupils—a course which is made up of material which everybody should know and whose methods furnish training calculated to produce certain qualities in the pupils. As I reflect upon the question, I am inclined to think that reliance upon such a course is vain, and that to produce permanent results, we must adapt the course to the capacities, tastes, experience, and so far as possible, future plans of the pupils. We urge the value of individual laboratory work in cultivating habits of observation, and skill in manipulation, and we insist on mathematical solutions as training in logical thought. Experience shows, however, that this work does not necessarily produce anything of the kind. We have all had pupils, I imagine, whose laboratory experiments were a thing entirely apart from the rest of life, and whose habits of observation were not affected in the least by their experience in performing the experiments required. I have had not a few pupils in mathematics who could be taught the necessary operations and types of problems to enable them to pass the examinations but of whom I was morally certain that, once the examinations were over, the mathematical knowledge would evaporate with great rapidity, leaving no increased power of logical thought, as far as anyone could see. On the other hand, we all have pupils whose progress is unquestioned and in all whose work we can see the effects of lessons which have struck deep. The point

is that the cultivation of powers in a pupil is not *assured* by the type of work which he goes through. If he catches the spirit of exact measurement, if it appeals to him as something admirable, and so affects his own standards of work, the end is attained. If he performs the experiments, seeking the degree of accuracy which the teacher prescribes, conscious of the difficulty of attaining this result, but not impressed by its intrinsic value, the mere performance of the experiment is not likely to change his future performance. Indeed, it may result in a positive distaste for such painstaking work. It is of the greatest importance that the pupil's study of physics strike home, influence his standards and his attitude toward things. The same treatment will not affect all pupils in the same way, and the single course, especially if, as is often the case, the work outlined is so great as to require the teacher to hurry from one topic to another, is not, I believe, an efficient instrument for the purpose stated.

This leads me to a word about the college entrance requirements. I recognize the very great benefit which the requirements in physics have brought to science teaching in the schools of the country. They have raised the standards in equipment, in the training of teachers, and in the quality of teaching, and have had a powerful influence affecting the introduction of science into the high school course. I think, however, that the requirements have already served their purpose in these particulars and that at present their influence is a restraining and narrowing one.

Nobody will admit that his sole purpose is to fit his pupils to pass college examinations. I always protested that that purpose was strictly secondary. Nevertheless, I am aware that the necessity of covering certain ground, for which there was none too much time, kept the examinations very near the level of consciousness for the pupils and myself. I was obliged to leave out matter that seemed valuable, and I was seldom able to follow out a topic beyond the restricted field of the text-book. A remark of one of my mathematics class illustrates the frame of mind which the examination requirements produce. While studying the principle of similarity, I explained the construction and purpose of the pantograph, devoted a lesson or two to a consideration of the principle of the instrument, and suggested that one of the boys construct one. At the second lesson, one of the pupils came to me and asked how much longer we were going to spend on the pantograph. I asked if he did not find

it interesting. "Yes." Valuable? "Yes, but it isn't required for college, is it?"

So long as teachers are required to give so large a part of their attention to covering ground, they are not in a position to improve the course much, and they have little encouragement to reflect upon the ultimate value of their work. A "loosening up" of the requirements which would permit a teacher, who has established a reputation for thoroughness, to vary his course considerably, shift the emphasis from one topic to another, or from one type of work to another would result, I am sure, in better preparation for college work, as well as greater progress toward his own ideals.

I know the difficulties of the certificate system and I do not propose to start a discussion on the subject of college entrance requirements. I merely wish to express my view that, whatever value the requirements may have in raising and maintaining standards in the schools, they do stand in the way of progress toward an understanding of the real purpose of science teaching and the means of attaining it. As the examinations are likely to hamper us for some time to come, the opportunity for progressive work lies with those who are not concerned exclusively with college preparation. The non-college courses have, as a rule, been modeled on the college preparatory plan, but I have no doubt that there will be an increasing tendency on the part of non-preparatory schools to plan their courses in accordance with their own needs.

My *vision* relates to the effect of the study of physics upon the pupil's attitude of mind. I can imagine a teacher inspiring his class to the extent of causing *them* to have visions. Indeed, that takes little imagination, for we all know a few such teachers; but there are times when I see how I could do something of that sort myself. At least I feel sure that I could come nearer to it than I used to do. If the study of science by high school students is to have its highest value, it must affect their emotions. Boys and girls of this age are capable of intense enthusiasm. It ought to be possible to arouse in them an enthusiastic appreciation of natural law, a sense of awe and admiration for the perfection of order and of relation in the universe, as well as an intense interest in man's effort to understand, to unravel the mysteries, to know. I think it is safe to say that very few pupils carry away anything of this sentiment from their study

of physics. On the contrary, many have acquired a deep dislike of the whole subject, a dislike which is strong enough to have its influence on younger pupils and to cause them to approach the work with something almost of fear. The average pupil thinks of physics as a certain text-book, experiments in specific gravity and boiling point, problems, etc. He has no greater love of nature, no conceptions of the vastness and perfection of the universe.

To attain the desired attitude on the part of the pupils is quite a different matter from seeing the vision, and I can only hint at possible ways of working toward it—ways which I think I should try if I had the chance. In the first place, it would be necessary to change the emphasis given to different topics and some of the topics commonly studied would have to go. The teacher would have to take time to make thoroughly clear the topics on which he relied to influence his pupils most, without feeling that by so doing he was getting behind his schedule. He should treat carefully some of the great laws of nature, like Conservation of Energy, or the Law of Gravitation, using plenty of illustration, and trying to give a conception of the magnitude and the perfection of order in the universe as expressed in these laws. When the laws are used as convenient expressions upon which to base problems, they arouse little enthusiasm. I venture to say that they can be so treated as to be a real inspiration, and, with the right emphasis and due care in presentation, numerical examples can be used to make the conception more definite and striking, even to the non-mathematical mind.

Historical material could be used to good advantage. Enough time should be taken to give some aspect of reality to the scientists of past centuries. A little study of the knowledge which men of the Middle Ages possessed would serve to disabuse pupils' minds of the impression that all scientific discoveries have been made within a few years. Then a rapid survey of the search for truth continuing from century to century, and of the sacrifice and even martyrdom which were suffered for truth's sake, should help to give an appreciation of the inheritance which we enjoy and a keen interest in present efforts to extend the frontiers of knowledge.

Besides the sense of reverence for the universal harmony, a pupil ought to leave the physics course with an interest in the physical phenomena and the applications of physical principles with which he comes in contact day by day, and with the ability

to use his knowledge of physics. To arouse this interest and to make it most effective, there is again need of differentiation. The things with which the pupil is familiar or with which he is most likely to deal after leaving school ought to furnish the illustrations for class work. The books have been adding much material which is of interest to the *boy*, but it is not surprising that alternators and gas engines have not the same attraction for the *girl*. It would be advisable, I think, to point out to girls as far as possible the applications of physics relating to the home. For example, in connection with specific gravity, the use of hydrometers for determining adulteration of milk, might well be substituted for the measurement of the specific gravity of a copper sulphate solution. In discussing machines, the egg beater, ice cream freezer, or sewing machine might well take the place of or supplement the usual illustrations. The water supply, plumbing, and heating systems are especially valuable topics to take up with girls. A rather more extended study of the principles of sound illustrated in musical instruments and of color suggest themselves to me as features of a course for girls.

In conclusion, I would repeat the points which I have emphasized—

(1) That physics should be presented so as to arouse enthusiasm, not simply as a disciplinary exercise.

(2) That differentiation is necessary in order to make the subject most effective, the work being adapted to the needs, tastes and experience of the pupils.

Enthusiasm is the chief product to be sought and the effort to produce it should be uppermost in the teacher's mind. The means employed is far less important and the teacher should be ready and free to vary subject matter and method to attain his end.

You will bear in mind that I have been confessing my own shortcomings and expressing my hope for better results than I have ever attained. I am aware that some of you are doing the very things which I would like to do. The obstacles which hampered me are, however, still in the path of many teachers, and taking the general view of physics teaching in the country to-day, I believe that no apology need be made for urging the need of a clearer understanding of real values to be gained by a study of science, and a more searching examination of actual results.

SYMPOSIUM ON THE PURPOSE AND ORGANIZATION OF PHYSICS TEACHING IN SECONDARY SCHOOLS.

XIII. BY PROFESSOR JOHN DEWEY,*

Columbia University, New York.

One not professionally or technically acquainted with a subject of instruction can, without presumption, only state the *points of view* from which he thinks that subject should be treated to obtain its maximum efficiency. With material so comprehensive and so detailed as that of physics, selections and rejections must in any case take place and take place from some standpoint. And the material thus selected must be brought to the student in a certain atmosphere of context and motive. Concerning these principles of selection and motivation a non-physicist may, perhaps, say a few words without trespassing where he has no business.

1. The importance of the social applications of physical science in modern life should be borne constantly in mind both in selecting and in presenting subject matter. The business of the high school is primarily a social business, not of creating a class of specialists. The public that pays taxes for the support of schools is justified in requiring that whenever it can be accomplished without doing violence to the subject taught, the subject shall be so taught as to make individuals more intelligent and hence more competent in doing their share in social life. Contemporary civilization rests so largely upon applied science that no one can really understand it who does not grasp something of the scientific methods and results that underlie it; on the other hand, a consideration of scientific resources and achievements from the standpoint of their application to the control of industry, transportation, communication, not only increases the future social efficiency of those instructed, but augments the immediate vital appeal and interest of the subject.

2. Scientific method in its largest sense is the justification on its intelligent side of science teaching, and the formation of scientific habits of mind should be the primary aim of the science teacher in the high school. Scientific methods in their largest

***With this article by Dr. Dewey the Symposium on Physics Teaching closes. The series of thirteen papers will be reprinted in pamphlet form and will be sent to any address on receipt of 10 cents.**

sense are more than matter of pure technique of measurement, manipulation and experimentation. There may come a peroid in the training of scientific specialists when these things for the time being become ends in themselves. In secondary education their value and hence their limits are fixed by the extent to which they react to create and develop logical attitudes and habits of mind. The methods of experimental inquiry and testing which give intellectual integrity, sincerity and power in *all* fields, rather than those which are peculiar to his specialty, are what the high school teacher should bear in mind. A *new type of mind* is gradually developing under the influence of scientific methods; the physics teacher should do what in him lies to hasten the extension and the supremacy of this type of mind.

I want to add a word about one aspect of the training on its logical side. Almost all intellectual subjects have inherited notions of *law* from earlier thought which are essentially "metaphysical" in character—in the bad sense of metaphysical. Laws are conceived either after the analogy of jural and legal ordinances as cast iron decrees which somehow "govern" facts and events; or else as mere sequences and coexistences that happen to be uniformly repeated in these facts and events. In the popular mind there is a fusion of these two views. Anyone who knows the history of philosophy can put his finger on the origin of these notions; they arose outside of science and were imported into science from outside. Conceived in either of these ways, laws lack intellectual vitality and significance. Instead of being organic aids to thinking, they mark fixed external limits that have been set to thinking. The very notion of law, in addition, becomes a confusing puzzle. Logically laws are the general methods by which we introduce continuity and order in experiences otherwise discrepant and mixed up. They are instrumentalities of bridging over the gaps in our experience of things; they are instrumentalities of reducing seeming conflicts to harmony. In other words, treat laws as *logical* tools and weapons and their wonderful value becomes self evident. Otherwise laws are metaphysical puzzles. Intellectual devices of introducing continuity and system laws *certainly* are; let us begin with what is certain; if laws are also more than logical instrumentalities, this surplus over and above the logical can safely be left for discussion when the student comes to metaphysical studies.

A UNIVERSAL PROJECTION LANTERN.

By E. J. Rendtorff,

Lake Forest Academy, Lake Forest, Ill.

The projection lantern is without exception the most essential piece of apparatus of the modern lecture room equipment for the teaching of science, and especially in the physics department. To meet the diversified demands of the teacher, the lantern must be able to project photographic slides, microscopic slides, apparatus both transparent or opaque by either horizontal or vertical projection, and printed diagrams of every nature. These various types of projection must frequently be alternated during a lecture. It is therefore of prime importance that a lantern projects everything directly forward, without rotating the lantern, and without alternating the objectives or other accessories, so that a change in type of projection can be made without much loss of time.

Some of the many other requirements of such a lantern are:

1. A large vertical gap for the projected apparatus.

2. A large 6″ front condenser, so that apparatus of some size can be projected.

3. A complete control of the position of the arc in all directions.

4. A control of the intensity of illumination.

5. A light proof, well ventilated covering over the arc, to render the image visible through contrast.

6. A rapid and optically accurate device for replacing condensers when broken, or of improper focal length.

7. A good ventilating device for the condenser cells.

8. No multiplicity of mirrors—especially in front of the objectives—that reduce the illumination and distinctness of the image.

9. Condensers, objectives and all other parts must be in optical alignment and sufficiently stable to remain in position.

10. Slide holders for postal cards, etc., that will prevent the warping due to heat.

11. A method for reinverting the image of projected apparatus.

Almost innumerable other requirements could be mentioned: the above are only a few of the most essential. For a universal lantern, adaptable to every conceivable use, the absolutely essen-

tial requirements are: First, the interchange from any one to any other type of projection in about one second of time; and second, results for each type of projection as nearly perfect as if the lantern were constructed for that one kind of projection only.

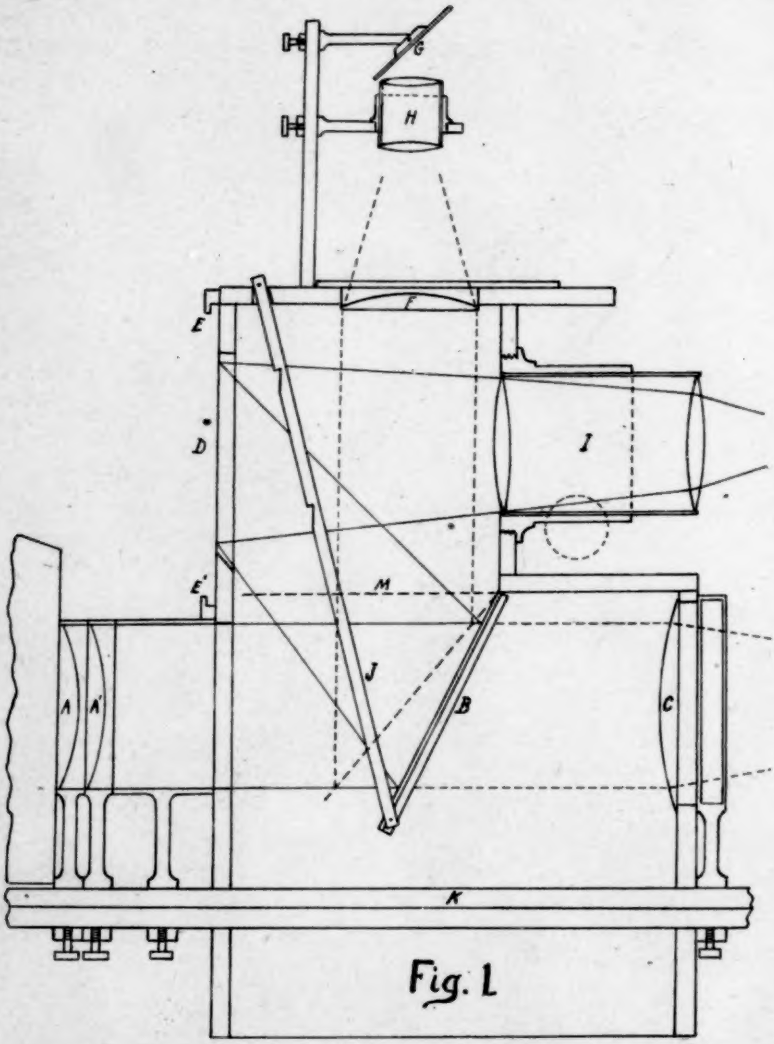


Fig. 1

Many good lanterns are on the market, but they are not sufficiently universal. This prompted me to make one that would more nearly meet the demands of the science teacher. The results obtained have been so uniformly successful as to warrant the writer making his ideas public.

Figure 1 represents a cross section of the lantern. The condensers A and A′ are 4½″ in diameter and of 5½″ and 6½″ focal length. Parallel light strikes the plane mirror B and is reflected to D, where the picture, or object to be projected, is held. The objective I has a back focus of about 8″ and magnifies an ordinary postal card, on a screen fifteen feet away, to about six feet square.

A lever J, with several notches cut in it, is fastened to the mirror B. On raising the lever to the second notch the mirror is adjusted at angle of 45° to the square optical bench K, so that the light passes vertically through the condenser F, the object to be projected, and the objective H. By means of the plane mirror G, the image is thrown on the screen wherever desired. Instead of this mirror a totally reflecting prism could be used advantageously.

On raising the lever to the last notch the mirror is elevated to M, so that the light passes directly through the large 6″ condenser C, in front of which are mounted the various accessories needed in any particular case. The vertical gap from the center of the front condenser to the optical bench is 6½″, but where a deeper one is required the optical bench can be made in two parts, with a short gap between the condenser and the objective.

A large 6″ condenser is used, so that apparatus of some size can be projected. The arc is then pushed somewhat closer to the rear condenser, so that the conjugate focus of C is moved outward, but this is advantageous, as the objective must also be moved in the same direction. When slides are projected the slide holder acts as a diaphragm and diminishes the chromatic aberration.

Figure 2 illustrates the lantern when mounted for use. The lighthouse is higher than necessary by about 4″ and is also too close to the dark chamber containing the adjustable mirror. It should be moved back about 4″, which could easily be done by placing an absorption cell or a metal frame between the rear condensers and the dark chamber. These alterations would give ample space for holding any opaque object, or illustrations from a book, at the opening from which these are projected, without any danger of burning the hands of the operator.

The double frame holding the objective used for projecting slides is hinged, so that it holds not only the regular ¼ plate objective, but a projecting microscope also. By means of the

hinge either the objective or the microscope can be swung into alignment, directly above the optical bench.

About one thousand illustrations from various catalogues and text-books were mounted on stiff black cardboard 4x5″ in size, and indexed. Holders for these cards were made of heavy black-

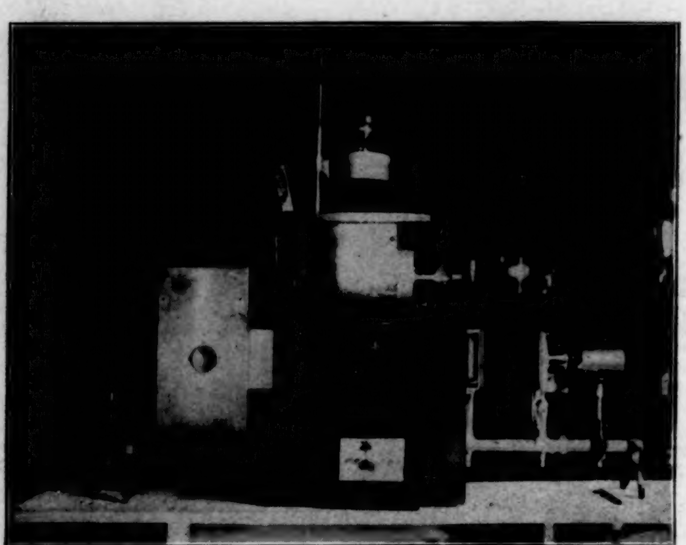


Fig. 2.

ened brass, as illustrated in Figure 3. By pushing on A, the strips B and B′ are raised slightly, so that the cards and a plate of tin can be pushed into position. On releasing A the cards are clamped tightly, so that the heating does not produce any appreciable warping and consequent deformation of the image. Two similar holders for illustrated postal cards were also made. These holders fit into the spring guides E and E,′ Figure 1, and can be replaced as rapidly as any photographic slide. An illustration from any book, or for that matter any object, can be shown by simply holding it inverted before the opening D, Fig. 1.

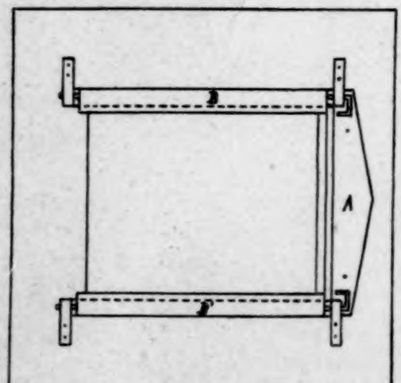


Fig. 3.

To interchange vertical, opaque and direct apparatus or photographic slide projection it is thus only necessary to set the lever J at the proper notch, while the microscope can be swung into alignment by merely turning the top part of the lower objective holder. A change from any one to any other type of projection can be made in about one second of time and in every case the image is formed directly in the center of the screen.

With a single phase, 60 period alternating current of about 20 amperes, the opaque projection of diagrams, illustrations and postal cards is very satisfactory, provided cored carbons are used and that the image is not over seven feet square. With the direct current the illumination is necessarily much better. In the latter case the positive carbon should be horizontal and the somewhat smaller negative carbon vertical. When the alternating current is employed both carbons should be of the same diameter and held at an angle of about 35° to the optical bench.

The above described lantern has been thoroughly tested during the last school year and, with the slight alterations suggested, meets all the conditions of simplicity, rapidity of operation, universality and efficiency that a teacher could possibly desire.

AN INTERESTING EXPERIMENT INVOLVING ARCHIMEDES PRINCIPLE.

By W. N. Mumper.

New Jersey State Normal, Trenton.

Take a demonstration hydrometer (or simply a wooden rod about 25 cm. long), and load one end with lead, if necessary, until it will sink when put into kerosene, but float when in water with about one-twelfth of its volume above water. Now place the loaded rod or hydrometer into a tall jar containing just enough water to float it (Fig. 1). Next pour kerosene into the jar on top of the water until the rod is entirely covered (Fig. 2). It

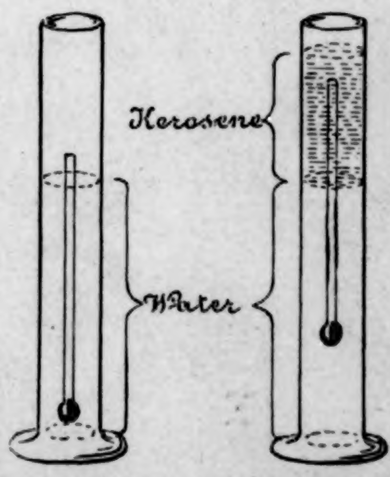


Fig. 1. Fig. 2.

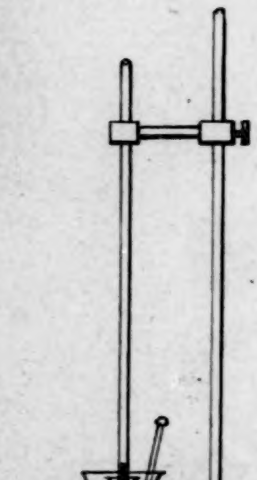
is interesting to consider (1) why the rod rises as the kerosene is being poured in and while it is pressing directly against the sides only. (2.) Why it stands highest when completely covered with kerosene. (3.) The relation between the weight of the rod or hydrometer and the weight of water displaced in Figs. 1 and 4, the relations between the weight of the rod and the weight of both water and kerosene displaced in Fig. 2.

A SENSITIVE THERMOMETER.

By Wilhelm Segerblom.

Phillips Exeter Academy, Exeter, N. H.

In the November number of School Science and Mathematics was an article on "A Useful Type of Thermometer" that leads me to mention a modified thermometer which I have used to advantage for lecture purposes. Probably many teachers have used a similar device, but I mention it on account of its simplicity and the ease with which it can be made from apparatus on hand in the ordinary laboratory. The apparatus consists of a fifty cubic centimeter flask, a one-hole rubber stopper and a piece of ordinary wash bottle tubing. The flask is filled to the brim with ether, which has been colored with a few crystals of iodine; when the stopper is pushed into place the ether rises in the glass tube and its height may be marked by slipping over the tube a narrow ring of rubber tubing. I have used this apparatus to good advantage in showing in a lecture experiment that sulphuric acid and water generate heat when mixed. In the apparatus I used in which the glass tube had an internal diameter of five millimeters the ether rose from fifteen to twenty centimeters, while the temperature of the mixture rose from ordinary room temperature to 65° or 70°. This rise in temperature was read from a centigrade thermometer immersed in the mixture beside the modified thermometer. With a glass tube of smaller bore the rise of the ether could be magnified.



PROBLEM DEPARTMENT.

IRA M. DELONG.

University of Colorado, Boulder, Colo.

Readers of the Magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to Ira M. DeLong, Boulder, Colo.

Algebra.

134. Factor $(x+y+z)^5-(x^5+y^5+z^5)$.

Solution by Ira P. Baldwin, Emporia, Kansas; James A. Whitted, Abingdon, Illinois, I. L. Winckler, Middlebury, Vermont.

The given expression is symmetric and homogenous. It vanishes when $x=-y$, $y=-z$, $z=-x$, and is, therefore, divisible by the symmetric, homogeneous function $(x+y)\ (y+z)\ (z+x)$. The quotient, being necessarily symmetric and homogenous, must be of the form $m(x^2+y^2+z^2)+n(xy+yz+zx)$.

Equating the product of the determined factors to the given expression, we have, for $x=y=z=1$,

$$m+n=10,$$

and for $x=y=1$, $z=0$,

$$2m+n=15,$$

whence $m=5$, $n=5$. Therefore

$$(x+y+z)^5-(x^5+y^5+z^5)=$$
$$5(x+y)(y+z)(z+x)(x^2+y^2+z^2+xy+yx+zx).$$

135. *Proposed by I. L. Winckler, Middlebury, Vt.*

Solve by quadratics,

$$x^2-y^2=a^2,\quad x^3+3xy^2=b^3.$$

1. *Solution by Orville Price, Denver, Colo.; W. T. Brewer, Quincy, Ill.*

We have

$$(x+y)^3+(x-y)^3=2(x^3+3xy^2)=2b^3,$$

and, from the first of the given equations

$$(x-y)^3=\frac{a^6}{(x+y)^3}.$$

Therefore

$$(x+y)^6-2b^3\ (x+y)^3+a^6=0,$$

and

$$x+y=(b^3\pm\sqrt{b^6-a^6})^{\frac{1}{3}}.$$

The latter equation, combined with $x^2-y^2=a^2$, gives the value of $x-y$, and then it follows easily that

$$x=\frac{1}{2}\left[(b^3\pm\sqrt{b^6-a^6})^{\frac{1}{3}}+\frac{a^2}{(b^3\pm\sqrt{b^6-a^6})^{\frac{1}{3}}}\right]$$

$$y=\frac{1}{2}\left[(b^3\pm\sqrt{b^6-a^6})^{\frac{1}{3}}-\frac{a^2}{(b^3\pm\sqrt{b^6-a^6})^{\frac{1}{3}}}\right]$$

II. *Solution by M. H. Pearson, Dothan, Ala.*

Subtracting the cube of equation (1) from the square of equation (2), and extracting the square root of the result gives us

$$3x^2y + y^3 = \pm\sqrt{b^6 - a^6} \;\ldots\ldots\ldots\ldots (3).$$

Add (3) and (2), and take the cube root,

$$x + y = (b^3 \pm \sqrt{b^6 - a^6})^{\frac{1}{3}}.$$

Subtract (3) from (2) and take the cube root,

$$x - y = (b^3 \mp \sqrt{b^6 - a^6})^{\frac{1}{3}}.$$

From the last two equations we find

$$x = \frac{1}{2}\left[(b^3 \pm \sqrt{b^6 - a^6})^{\frac{1}{3}} + (b^3 \mp \sqrt{b^6 - a^6})^{\frac{1}{3}}\right]$$

$$y = \frac{1}{2}\left[(b^6 \pm \sqrt{b^6 - a^6})^{\frac{1}{3}} - (b^3 \mp \sqrt{b^6 - a^6})^{\frac{1}{3}}\right].$$

Geometry.

126. *Proposed by A. W. Rich, Worcester, Mass.*

Given a triangle ABC on whose sides as bases are drawn isosceles triangles whose base angles are 30°. Prove that the triangle formed by the vertices of the isosceles triangles is equilateral.

Remark by L. Leland Locke, Brooklyn, N. Y.

A great many other theorems may be enunciated regarding the complete figure as above constructed. We have, for example:

I. The equilateral triangle formed by joining the median points of the outer set of triangles, the corresponding equilateral triangle for the inner set, and the original triangle have the same median points.

II. By proper choice of one vertex of the outer equilateral triangle, one of the inner, and either of two of the original, a set of three equilateral triangles is obtained.

III. One side of each of these triangles bisects at right angles (and is so bisected by) a side of the original triangle.

136. *Proposed by C. Z. Aughenbaugh, Woodstock, Ill.*

ABCD is a parallelogram, Y any point on AB between A and B, X any point on CD between C and D. Let PY intersect AX in P, and YC intersect XB in Q. Let PQ intersect AD in M and BC in N. Prove that MN divides the parallelogram ABCD into two equal parts.

Solution by I. L. Winckler, Middlebury, Vt.

1. Let MN produced cut AB and CD, produced, in R and S, respectively.

Then AR:BQ:XP=BR:XQ:AP .... (1)

and DS:YP:CQ=CS:DP:YQ .... (2)

Since a line cutting the sides of a triangle determines upon the sides six segments, such that the product of three non-consecutive segments is equal to the product of the other three.

Also from the similar triangles APY and DPX, we get, AP:DP= XP:YP .... (3)

and from similar triangles BQY and CQX YQ:XQ=BQ:CQ...... (4)

Multiply (1), (2), (3), and (4).

$$AR:DS = BR:CS$$

$$\text{or}\quad (AB+BR)\times DS = (CD+DS)\times BR$$

$$\therefore DS = BR$$

$$\therefore \triangle DSM = \triangle BRN$$

$$\therefore DM = BN \text{ and } AM = CN$$

$$\therefore \text{Trapezoid } DMNC = \text{trapezoid } AMNB$$

II. Let $AB = a$, $AD = b$.

Taking AB and AD as axes of X and Y, respectively, let $X = (x_1, b)$ and $Y = (x_2, o)$

The equation of AX is $y = \dfrac{bx}{x_1}$

" " " DY " $\dfrac{x}{x_2} + \dfrac{y}{b} = 1$

" " " BX " $\dfrac{y-b}{x-x_1} = \dfrac{-b}{a-x_1}$

" " " CY " $\dfrac{y}{x-x_2} = \dfrac{b}{a-x_2}$

The intersection of AX and DY is

$$\left(\frac{x_1x_2}{x_1+x_2}, \frac{bx_2}{x_1+x_2}\right)$$

The intersection of BX and CY is

$$\left(\frac{a-x_1x_2}{2a-x_1-x_2}, \frac{ab-bx_2}{2a-x_1-x_2}\right)$$

The equation of the line through these points is

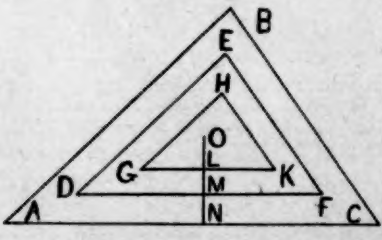
$$\frac{(x_1+x_2)y - bx_2}{(x_1+x_2)x - x_1x_2} = \frac{b(x_1-x_2)}{ax_1 - 2x_1x_2 + ax_2}$$

This line passes through $\left(\dfrac{a}{2}, \dfrac{b}{2}\right)$ the mid-point of the diagonals and therefore bisects the area of the parallelogram.

137. *Proposed by E. L. Brown, M.A., Denver, Colo.*

The lengths of the sides of a triangular field are a, b, and c feet. A farmer commences at one corner in the morning and plows m furrows n inches wide around the field in the forenoon. How many furrows must he plow around the field in the afternoon to turn over the same area as in the forenoon?

Solution by Proposer.



Let s = perimeter of field, A its area, and $r = ON = \dfrac{2A}{s}$, the radius of the inscribed circle. Let $MN = w = \dfrac{mn}{12}$ ft., the width of the strip plowed around the field in the forenoon. Let x = area of triangle DEF, y = the distance OL, and z = the distance LM, width of the strip to be plowed in the afternoon.

Since triangles ABC and DEF are similar, we have

$$A : x = ON^2 : OM^2 = r^2 : (r-w)^2.$$

$$\therefore x = A(r-w)^2 \div r^2.$$

Area plowed in forenoon = ABC—DEF

$$= A - \frac{A(r-w)^2}{r^2}$$

$$= \frac{Aw(2r-w)}{r^2}.$$

Area of GHK = DEF — area plowed in forenoon

$$= x - \frac{Aw(2r-w)}{r^2}$$

$$= \frac{A(r^2-4rw+2w^2)}{r^2}.$$

Since triangles ABC and GHK are similar, we have

$$A : \frac{A(r^2-4rw+2w^2)}{r^2} = ON^2 : OL^2 = r^2 : y^2.$$

$$\therefore y = \sqrt{r^2-4rw+2w^2}.$$

Therefore $z = LM = OM - OL = r - w - \sqrt{r^2-4rw+2w^2}$ ft., width of strip to be plowed in the afternoon. The width of one furrow $= \frac{n}{12}$ ft. The number of furrows to which the width z is equivalent, is the same as the number of rounds to be plowed in the afternoon.

This number equals $\frac{12}{n}\left(r - w - \sqrt{r^2-4rw+2w^2}\right)$, in which r and w are known functions of the given elements.

138. *Proposed by Arnold Emch, Ph.D., Solothurn, Switzerland.*

Two parallel planes intersect a sphere in circles whose diameters are AB= c_1 and CD=c_2, the distance between the planes being h. Find the intercepted volume as the difference of two spherical segments.

Solution by G. B. M. Zerr, Ph.D., Philadelphia, Pa.

This problem is solved in Wentworth's Solid Geometry in very elegant manner.

Let D = height of segment diameter c_1, d = height of segment diameter c_2, $c_1 > c_2$, R = radius of sphere.

Volume segment height $D = \pi D^2(R - \frac{D}{3})$

" " " $d = \pi d^2(R - \frac{d}{3})$

Volume required $= \pi R(D^2-d^2) - \frac{\pi}{3}(D^3-d^3) = V$

$$= \pi(D-d)\left\{Rd + Rd - \tfrac{1}{3}(D^2+Dd+d^2)\right\}$$

$D-d=h$, $D^2-2Dd+d^2=h^2$ or $D^2+Dd+d^2=h^2+3Dd$

$\therefore V = \pi h(RD+Rd) - \frac{\pi h}{3}(h^2+3Dd)$

$(2R-D)D = \frac{1}{4}c_1^2$, $(2R-d)d = \frac{1}{4}c_2^2$

$\therefore RD = \frac{1}{8}c_1^2 + \frac{1}{2}D^2$, $Rd = \frac{1}{8}c_2^2 + \frac{1}{2}d^2$

$\therefore RD + Rd = \frac{1}{8}(c_1^2+c_2^2) + \frac{1}{2}(D^2+d^2)$

$= \frac{1}{8}(c_1^2+c_2^2) + \frac{1}{2}(h^2+2Dd)$

$$\therefore V = \frac{\pi h}{8}(c_1^2+c_2^2) + \frac{\pi h}{2}(h^2+2Dd) - \frac{\pi h}{3}(h^2+3Dd)$$
$$= \frac{\pi h}{8}(c_1^2+c_2^2) + \frac{\pi h^3}{6}.$$

CREDIT FOR SOLUTIONS RECEIVED.

Geometry 126. E. L. Brown, L. Leland Locke. (2)
Algebra 128. E. E. Wood. (1)
Algebra 129 Roswell W. Rogers, E. E. Wood. (2)
Algebra 130. E. E. Wood. (1)
Geometry 131. G. A. L'hommedé. (1)
Geometry 132. E. E. Wood. (1)
Algebra 134. Ira P. Baldwin, E. L. Brown, Walter L. Brown, G. E. Congdon, W. L. Malone, James A. Whitted, I. L. Winckler, G. B. M. Zerr. (8)
Algebra 135. W. T. Brewer (2 solutions), E. L. Brown, Walter L. Brown, G. E. Congdon, A. M. Harding, W. Lee Jordan. W. L. Malone, Arthur L. McCarty, M. H. Pearson, Orville Price, O. R. Sheldon, Jas. H. Weaver, I. L. Winckler, A. L. Womack, G. B. M. Zerr. Also one incorrect solution. (17)
Algebra 136. T. M. Blakslee (3 solutions), E. L. Brown. Walter L. Brown, I. L. Winckler (2 solutions), G. B. M. Zerr. (8)
Geometry 137. E. L. Brown, Walter L. Brown, W. L. Malone, M. H. Pearson, Orville Price, O. R. Sheldon, I. L. Winckler. G. B. M. Zerr. (8)
Geometry 138. E. L. Brown, Walter L. Brown, T. M. Blakslee. G. B. M. Zerr. (4)
Total number of solutions, 53.

PROBLEMS FOR SOLUTION.

Algebra.

Two quantities vary directly and inversely as x respectively. If their sum is equal to 7 when $x = 2$, and to -13 when $x = -3$, what are the quantities?

Proposed by W. T. Brewer, Quincy, Ill.

Reduce to a quadratic equation and solve $x^3-42x^2+587x-2730=0$

Geometry.

Proposed by E. E. Wood, Fort William, Ontario.

Given two intersecting straight lines and a point P not on either line. Draw an equilateral triangle with one vertex at P, the others, one each, on the given lines.

Proposed by Walter L. Brown, Fancher, N. Y.

Given the perpendiculars from the vertices of a triangle upon the opposite sides to construct the triangle.

Miscellaneous.

Proposed by H. E. Trefethen, Kent's Hill, Maine.

A roofer is making an open gutter with the sides each 4 inches in slant height and the level bottom 4 inches across. What shall be the distance between the sides at the top in order for the gutter to carry the largest volume of water?

SCIENCE QUESTIONS.

BY FRANKLIN T. JONES,

University School, Cleveland, Ohio.

Please send lists of the laboratory exercises in physics you will use this year. Numerous and representative answers are desired.

The questions in this department will hereafter be consecutively numbered. In answering kindly refer to questions by number.

1. *Proposed by the Editor.*

Is the secondary school teacher in science hampered or assisted in his work by the college entrance requirements? Are the latter of the right kind? Do they prevent a teacher from doing pretty much as he pleases? (Repeated from the February issue.)

2. *Proposed by O. R. Sheldon, Chicago, Ill.*

A nail can be driven into an elastic body with a wooden mallet, but not with an iron hammer. Why?

3. *Proposed by J. Hawley Aiken, Saratoga Springs, N. Y.*

A uniform stick 24 cm. long, weighing 30 gm., has a piece of metal attached to one end. The stick then balances 5 cm. from this end. If the metal is submerged in water it balances 5.38 cm. from the end. Find the specific gravity of the metal.

4. *Proposed by O. R. Sheldon, Chicago, Ill.*

A common kite, concave in front, will not fly. Why?

5. *Proposed by O. R. Sheldon.*

A ball bounds a finite distance, and, in each succeeding bound, rebounds one half the distance of the preceding bound. Will it ever come to rest?

Solution of the "train and rifle problem," (see June and December, 1908, issues), by H. N. Pearce, Bloomington, Ill.

In the train and rifle problem, if the second law of motion is true, there is no question about the final result. When fired either way the bullet will strike its man (or the man the bullet) at the end of one minute. When fired forward with the sights of the rifle properly elevated, the bullet would describe the same curve as when fired on the ground. When fired backward the horizontal velocity becomes zero, but its vertical velocity remains the same and the bullet would rise vertically to the highest point of its range and fall vertically back in season to be hit by the man on the rear car when he arrives at the end of the minute.

[Is this solution inconsistent with the solutions published in the June and December, 1908, issues? If so, how? *Ed.*]

ENTRANCE EXAMINATION IN PHYSICS.
September, 1908.
Columbia University.

NOTE.—Time: Two hours. Candidates are required to present their notebooks on the thirty-five experiments as a part of the examination. Answer ten of the following questions as briefly as is consistent with clearness and definiteness. Explain all symbols used.

1. A boy throws a ball vertically upward, and four seconds later it strikes the earth. What height did the ball attain, and with what velocity did it leave the boy's hand?

2. A dog hitched to a cart can exert a pull of 10 Kg. With what velocity must the dog move in order to do work at the rate of twenty kilogrammeters per second? Name and define the c.g.s. units of force, work, and power.

3. A twenty-gram weight attached to one end of a uniform rod 100 cm. long causes it to balance about a point 20 centimeters from that end. Find the weight of the rod.

4. A string has its two ends attached to points 100 cm. apart in a horizontal plane. At the middle point of the string is attached a weight of 5 Kg., and the point is twenty centimeters below the horizontal plane. Find, by graphical solution, the tension on the string. Suggestion—Let the distance between the lines of the examination book represent 10 cm. and 1 Kg. respectively.

5. What is the atmospheric pressure in grams per square centimeter when the barometer stands at 76 cm.? Density of mercury equals 13.6 gr./cm.^{3}

6. A rectangular block of stone, 20x30x40 cm., has a density of 2.0 gr./cm.^{3} What force will be required to lift this block under water?

7. What must be the length of an open organ pipe that will give a fundamental note of 200 vibrations per second, if the velocity of sound in air is 300 meters per second?

8. A piece of copper weighing 200 grams is taken from an oven and placed in 500 cubic centimeters of water. The temperature of the water is changed from 20° C. to 30° C. If the specific heat of the copper is 0.09, what was the temperature of the oven?

9. Draw optical diagrams showing the path of the rays in the formation of a real image by a double convex lens, and of a virtual image by a double concave lens.

10. Draw a diagram showing the path of the rays in the formation of a spectrum by a prism, and indicate the position of the colors.

11. Draw a diagram of the parts and connections of an electric door bell.

12. Draw a diagram showing the principal parts and connections of a simple type of dynamo.

Entrance Examination in Zoölogy.
September, 1908.

Note.—Time: Two hours, ten minutes of which will be devoted to a practical oral examination.

1. Explain what is meant by evolution—natural selection—inheritance of acquired characters.

2. Enumerate the chief distinguishing characters of fishes, amphibians, reptiles, birds and mammals.

3. Discuss the process of digestion in man.

4. Compare the chief systems of organs in the earthworm and the frog and illustrate by means of diagrams. (The crayfish may be substituted for the earthworm if preferred.)

5. Explain how respiration takes place in clam, crayfish, grasshopper, fish and frog.

6. Give the general classification of the following—porpoise, paramecium, jelly fish, spider, seal, turtle, earthworm, oyster, salamander, snail, lobster, roach.

POSTAGE AND THE POSTAL UNION.

At the last triennial meeting of delegates to the International Postal Union, held at Rome in 1907, postal rates were somewhat changed. Previous rates for first class matter were five cents for each 15 grams (about half an ounce) or fraction thereof, but the Union, through its delegates, fixed a 5-cent rate for the first ounce and a 3-cent rate for each subsequent ounce or fraction. A like rate—so far as the "coin of the realm" allows—applies to correspondence between any states in the Union, and, as every commercial nation is a member of that body (which was formed in 1874), letters to any part of the world, except the Cannibal Islands or the Polar regions, have approximately the same rate. But maximum weights for letters are different.

First we notice, not without regret, the substitution of the ounce for grams, so that postmasters no longer have use for the scale beam graduated to grams, but all foreign matter, as well as domestic, is now weighed in ounces and fractions. The Assistant Postmaster General writes that this was done "because the Metric system of weights is not in general use in this country." He also says: "The unit of weight is greater in this country than in any other country except Great Britain and the British Colonies." "The unit of weight adopted by other countries is either 15 grams or 20 grams. In no country has 30 grams been adopted as the unit of weight."

A difficulty heretofore confronting any one wishing a response from a foreign correspondent has been that no International stamp existed to enclose for reply. This embarrassing trouble was met by the Postal Congress authorizing the issue of "International coupons," sold in this country at 6 cents each and redeemable at any post office in the world for the value of 5 cents, *i. e.*, for a stamp of the country. The coupons are sent to an international clearing house in Switzerland, the various countries being accredited for the number of stamps turned in and the extra one cent going to pay expenses of clearing.

Since the meeting of the International Congress progress has been made along the lines of reciprocity. The Postmaster General last summer concluded arrangements with Great Britain whereby a 2-cent rate went into effect Oct. 1, 1908, between the United States and the British Isles, though not applying to British possessions elsewhere. So favorably did the plan work from the start that a similar arrangement was entered into with Germany. Correspondence between that country and this, beginning Jan. 1, 1909, needs only a 2-cent stamp for an ounce, but all such letters must go by German boat direct, and not via England or France. No doubt the plan will soon extend to all members of the Union.

R. P. W.

THE WORK OF THE COMMITTEE ON REAL APPLIED PROBLEMS IN ELEMENTARY ALGEBRA AND GEOMETRY.

JAMES F. MILLIS, *Chairman, Francis W. Parker School, Chicago.*
J. V. COLLINS, *State Normal School, Stevens Point, Wis.*
C. I. PALMER, *Armour Institute, Chicago.*
E. FISKE ALLEN, *Teachers College, New York.*

At the meeting of the Mathematics Section of the Central Association of Science and Mathematics Teachers, November 27-28, 1908, a committee was created to investigate the possibilities of gathering up the real applied problems of elementary algebra and geometry in life and of using them in teaching the subjects in the secondary school.

COÖPERATIVE EFFORTS OF ALL TEACHERS NEEDED.

It must be evident to all teachers of secondary mathematics that in the present strong tendency toward a practical and rational education, there is no work greater needed in secondary mathematics to-day than the investigation assigned to this committee. It must be evident also that the nature and magnitude of the undertaking are such as to demand the coöperative efforts of all teachers, and of others if possible. To collect and place in the hands of teachers for class room use a large and valuable body of the real applied problems of elementary algebra and geometry that are found in the various vocations, industries, sciences, and arts, must be the work of many hands. The committee must of necessity serve as a sort of clearing house in the investigation.

SIGNIFICANCE OF THE REAL PROBLEM MOVEMENT.

This movement to vitalize secondary mathematics by teaching in the school the applications of the subjects to the problems actually encountered by people in everyday life, in the various trades, in science, etc., is an attempt to make school work function in a practical way in the life of the individual. It is a phase of the present general reform movement in the teaching of secondary mathematics that is really fundamental to the others. It must be considered in the elimination and choice of subject-matter of mathematics in the school. The selection of subject-matter must to an extent be determined by its relative importance in the actual applications in life. It is a fundamental phase of the movement to unify secondary mathematics. Mathematics is unified in its practical applications. Some real problems involve both algebra and geometry. Such unification as exists in the practical applications will be preserved if these applications are brought into the school and used. Such unification is of the most genuine kind. *Mathematics as taught in the school should give a true conception of the mathematics that is actually used in the various human undertakings.*

Again, the old idea that education is a discipline of the general faculties of the mind, such as reasoning and memory, as a preparation for the future alone, is being abandoned. Formerly the motive and defense in teaching algebra and geometry was that of "mental dis-

cipline," looking primarily to the future. Geometry, for example, has always been taught as an abstract, deductive science in the secondary school, for the purposes of training the "reasoning powers," and sometimes in the hope that possibly in adult life, after leaving school, the pupil might find some practical use for it. It has continued all these years with practically the old Greek content. The pupil's present needs and interests have not been taken into account. But it is demanded to-day that in teaching secondary mathematics, as has long been the practice in teaching arithmetic, these present needs and interests shall be taken into account. In teaching algebra and geometry the selection of the subject-matter and of methods must be dependent upon both the pupil's present needs and interests and his future ones. The ordinary high school pupil is interested in algebra and geometry not as abstract sciences, but rather as *tools for solving the problems actually encountered by people in the various human undertakings.* He is interested in life itself, in how things are done in the practical world. This means that we must not keep algebra and geometry as abstract sciences, totally unrelated to human affairs, but must as far as possible *teach them in relation to their actual uses.* Let the pupil see that they are indispensable tools in doing the world's work.

To express the matter in a slightly different way, the true educative process not only begins with experience but ends with experience. It is here that the secondary school has failed to meet its obligations. It is the duty of the school not only to put the pupil into possession of the bodies of knowledge called algebra and geometry in a rational and interesting way, *but to teach him in the school how to make the applications of this knowledge in the solutions of real problems—to assist this knowledge to function.*

It is evident, then, that the work which the Association has undertaken to do, through this committee, is of fundamental interest to all teachers of secondary mathematics. And it is a work in which it is hoped that all teachers of mathematics will be anxious to assist.

Where Applied Problems May Be Found.

The fields in which the applied problems of algebra and geometry are to be found are many. Some problems, of course, will be encountered in other school subjects, such as manual training and physics. Problems will be found in the various building trades, such as carpentry and masonry, in bridge building and roofing, in civil engineering, in railroading, in machine-shop work, in navigation, in elementary astronomy, in architecture, in ornamental drawing, in manufacturing, in the principles underlying the use of measuring instruments, and in ordinary every day activities. In fact, they are apt to be discovered in most any corner, if one is on the lookout for them.

Types of Problems, and Illustrations of Them.

There are two types of applied problems in algebra: (1) those requiring an evaluation of a formula or function; (2) those requiring the solution of an equation or equations.

There are three types of applied problems in geometry: (1) those requiring a demonstration; (2) those requiring a construction to be made; (3) those requiring a computation based upon a geometrical fact. Of these types, the problems of the third are most easily found. It is urgent that teachers collect especially problems of the first two types in both plane and solid geometry.

An illustration of real problems requiring the evaluation of an algebraic formula is as follows:

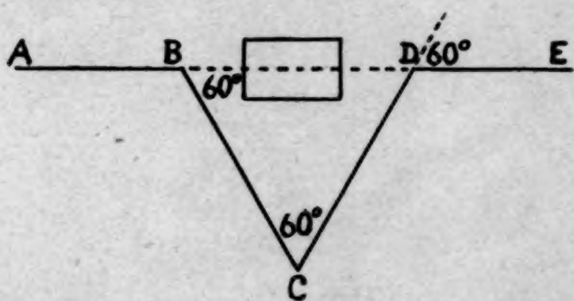
1. The horse-power of a steam engine is obtained by use of the formula H. P. $= \frac{p.l.a.n}{33,000}$, where $p =$ the mean effective pressure in pounds per sq. in., $l =$ length of stroke in feet, $a =$ area of piston in sq. in., and $n =$ twice the number of revolutions per minute. Compute the H. P. of an engine in which a test showed p to be 60lb. per sq. in., $n = 180$, the area of the piston was 324.2 sq. in., and the length of stroke 28 in.

The following illustrates a type of applied problem in scientific dairy farming that may be solved by use of an equation:

2. A dairy cow requires 1 lb. of protein to 6 lb. carbohydrates in her food. Dry peas contain 10 lb. protein and 32 lb. carbohydrates per bu. (60 lb.) Hay contains 88 lb. protein and 880 lb. carbohydrates per ton. What should be the proportion of the quantities of dry peas and hay fed to a dairy cow, if these are to constitute her ration? (From the Stone-Millis Secondary Arithmetic.)

The following illustrates the type of geometry problem requiring a demonstration:

3. Justify the following method used in surveying a line AB beyond an obstacle, such as a building:

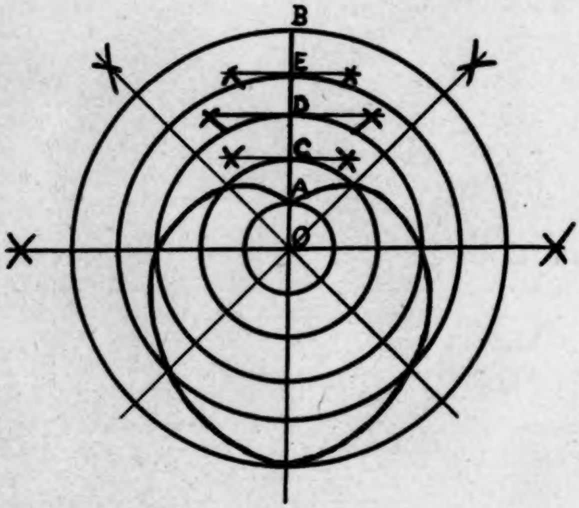


Measure off an angle of 60° at B, and measure BC sufficiently long to clear the obstacle, as in the diagram. At C construct an angle of 60°, and measure CD=BC, as in the diagram. Then at D measure an angle of 60°, giving DE. DE is the desired prolongation of AB.

The following illustrates the type of geometry problem requiring a construction:

4. To construct the pattern of a uniform-motion cam with a given throw and given maximum radius. (A wheel having its axis of revolution out of its center of figure. Cams are found in the printing press, sewing machine, etc.)

Let the given throw be AB, and the greatest radius OB. Divide AB into any number n of equal parts, at points C, D, etc. Through A, C, · · · B. draw circles with centers at O. Draw rays dividing the angular magnitude about O into $2n$ equal angles. Beginning at A. mark the points where the consecutive circles and consecutive rays



intersect, and through these points draw a smooth curve, as in the diagram. Let the student draw the pattern of such a cam with throw equal to a given line l and greatest radius equal to a given line m.

How Teachers may Aid in this Investigation.

Individual teachers may find such applied problems as these, (1) by going into the machine shops, etc., where they are encountered; (2) by consulting men actively engaged in the various trades; and (3) by consulting trade journals and books on the building trades, sheet-metal work, applied mechanics, mechanical and industrial drawing, surveying, and the like.

In this work the committee have arranged to utilize this space in School Science and Mathematics every month, to carry on the investigation for the Association. *Teachers everywhere are urged to send to the Committee every month all of the real problems that they can find. These problems, or as many as there will be room for, will be printed in* School Science and Mathematics *each month, and proper credit given the contributors.* It is the hope of the Committee to print in pamphlet form for distribution with its report, at the next meeting of the Association all of the real problems thus contributed, giving credit to the contributors. It ought to be possible by such coöperative efforts of a large body of teachers working together to soon place in the hands of all teachers a valuable collection of the real applications of algebra and geometry for class room use.

It is earnestly hoped that every teacher of secondary mathematics will assist in this work. Do not wait until you get a large collection of problems before sending them, but begin at once. In all cases where problems are taken from trade journals or books, the contributor will please note the name of the publisher, etc.

Send all problems to James F. Millis, Francis W. Parker School, Chicago.

ARTICLES FROM CURRENT MAGAZINES.

American Naturalist: "Charles Darwin and the Mutation Theory," Charles F. Cox; "Juvenile Helps and the Recapitulation Theory," Robert F. Griggs.

Astrophysical Journal, January: "Notes on the Possibility of Fission of a Contracting Rotating Fluid Mass," F. R. Moulton; "Vertical Temperature—Gradients of the Atmosphere, Especially in the Region of Upper Inversion," W. J. Humphreys; "The Constitution of the Sun," J. F. H. Schulz; "Interaction of Sun-Spots," P. Fox and G. Abetti; "On the Absorption of Light in Space," J. C. Kapteyn; "Spectrum of Comet Morehouse" (1908c), E. B. Frost and J. A. Parkhurst; "Photographic Observations of Comet (c 1908) Morehouse," E. E. Barnard; "On the Colors of some of the Stars in the Globular Cluster M 13 Herculis," E. E. Barnard; "On the Separation in the Magnetic Field of some Lines Occurring as Doublets and Triplets in Sun-Spot Spectra," A. S. King; "The Spectrum of Comet (c1908) Morehouse," W. W. Campbell and S. Albrecht.

The Auk for January: "Notes on the Occurrence of the Yellow Rail in Michigan," Norman A. Wood; "Nesting of the Bohemian Waxwing," R. M. Anderson; "Some Habits of the English Sparrow," C. W. Townsend; "Instinctive Stillness in Birds," William Palmer.

Botanical Gazette for January: "On Triple Hybrids," Hugo de Vries; "Periodicity in Spirogyra," W. F. Copeland; "On the Pollen of Microcachrys Tetragona," R. B. Thomson; "A Vegetative Mutant, and the Principle of Homoeosis in Plants," R. G. Leavitt.

Conservation for January: "The Joint Conservation Conference;" "The Conference Proper;" "The Rivers and Harbors Congress."

Industrial Education for January: "Relation of Industrial Education to National Progress," Booker T. Washington; "The Work of the National Society for the Promotion of Industrial Education," Carroll D. Wright; "Vocational Training and Trade Teaching in the Public Schools," James P. Haney; "Elementary Trade Teaching," Charles H. Morse.

Manual Training Magazine for February: "Engineering and Industrial Problems as Factors in Seventh and Eighth Grade Manual Training," Albert F. Siepert; "The Construction and Flying of Kites," Charles M. Miller; "Simplified Mechanical Perspective," Frank F. Frederick.

Physical Review for February: "The Coefficients of Gas Viscosity, II," Willard J. Fisher; "The Effect of Tension on Thermal and Electrical Conductivity," N. E. Smith; "A Study of Overcast Skies," Edward L. Nichols; "Note on the Short-Circuiting of Cadmium Cells," P. I. Wold; "The Dispersion of Electric Double Refraction," T. H. Havelock.

Popular Science Monthly for February: "The National Exposition at Rio de Janeiro," Professor Robert DeC. Ward; "A Biographical History of Botany at St. Louis, Missouri," Dr. Perley Spaulding; "The Latest Calabrian Disaster," Professor William H. Hobbs; "Jefferson Davis's Camel Experiment," Professor Walter L. Fleming; "Railroads and the Smoke Nuisance," Clinton Rogers Woodruff; "Account of a Trip in Southernmost Japan, with Early Records of its Discovery," Robert Van Vleck Anderson; "An American Contribution to the History of the Physiology of Digestion," Professor Lafayette B. Mendel; "The Instruments and Methods of Research," Dr. L. A. Bauer.

School of Review for February: "What the University Expects of the Secondary School," John M. Coulter; "Report of the Conference Committee on High-School English," John M. Crowe, Mrs. E. K. Broadus, James F. Hosic; "Elementary Science in the High School," Elma Chandler; "Making Botany Attractive," Willard N. Clute; "The Year's Progress in Mathematics in the University High School," G. W. Myers.

THE AMERICAN FEDERATION OF TEACHERS OF THE MATHEMATICAL AND THE NATURAL SCIENCES.

The Council of the Federation met in Baltimore, Md., on Monday, December 28, at 3 P. M. Of the thirty-three members of the Council, nineteen were present either in person or by proxy. The report of the Executive Committee, presented by Mr. J. T. Rorer, outlined the work of the year in connection with organization, the appointment of a special committee on the bibliography of science teaching, the issue of the November Bulletin, and the preparations for the council meeting in Baltimore. It pointed out some of the specific questions which might naturally engage the attention of the officers of the Federation during the coming year; emphasizing, however, the dependence of successful work on increased financial resources.

The treasurer reported a balance of $20.20 from last year, as shown in the printed statement in the Bulletin. The printing and mailing of the Bulletin had cost up to date $53, leaving $32.80 chargeable to this year's account. Dues from the federated associations for last year had been paid, but had not yet been collected for the current year. An auditing committee, consisting of Messrs. L. S. Hulbert and C. H. Smith, was appointed, and reported later that the accounts were correct.

Interesting reports in regard to organization and methods of work were presented from the following local societies: The Association of Mathematical Teachers in New England, presented by Mr. W. T. Campbell; The Association of Teachers of Mathematics of the Middle States and Maryland, presented by Mr. Eugene R. Smith; The Physics Club of New York, by Mr. F. B. Spaulding; The Association of Biology Teachers of New York, by Mr. G. W. Hunter; The Association of Physics Teachers of Washington, D. C., by Mr. W. A. Hedrick; The New England Association of Chemistry Teachers, by Mr. H. P. Talbot; The Central Association of Science and Mathematics Teachers, by Mr. C. H. Smith; The Colorado Mathematical Society, by Mr. G. B. Halsted; The Southern California Science Association, by Miss T. A. Brookman. All the reports showed active and constructive work under way.

By unanimous consent the following article was added to the articles of federation as adopted at the Chicago meeting:

13. These articles may be amended at any annual meeting of the council by a two-thirds vote of the members present provided notice of the proposed amendment has been sent to all members of the council and to the president and secretary of each federated society at least thirty days prior to the meeting.

The following resolutions were unanimously passed:

Resolved: That the American Federation of Teachers of the Mathematical and the Natural Sciences respectfully urges upon the Congress of the United States the enactment of such legislation as will greatly increase the scope and importance of the United States Bureau of Education and will enable it to render immediate and effective aid in the promotion of education in the mathematical and the natural sciences; and

Resolved: That the Executive Committee of the Federation be authorized to take such action as may seem to it desirable to further such action by Congress.

Three committees of the Federation were authorized as follows: One on a syllabus of propositions in geometry. One on publication and publicity, to report next year on the present needs and facilities for publishing material of interest to the Federation, and to make such recommendations as to ways and means of improving these facilities. The third, a committee to investigate the present conditions of college entrance, to define the attitude of the Federation toward college entrance problems, and to recommend action that may tend to unify and simplify the college entrance requirements.

The following were then unanimously elected officers for the coming year: President, H. W. Tyler, Massachusetts Institute of Technology; Secretary-treasurer, C. R. Mann, University of Chicago; other members of the Executive Committee, G. W. Hunter, DeWitt Clinton High School, New York; J. T. Rorer, Central High School, Philadelphia; C. H. Smith, Hyde Park High School, Chicago.

Professor R. E. Dodge presented a report of progress from the Committee on Bibliography, showing that the sections on mathematics, physics, biology, and geography were nearly completed.

A letter from Professor D. E. Smith, representing the International Commission on the teaching of Mathematics, was presented, expressing the hope that the Federation would coöperate in its undertaking in due time.

On Tuesday morning, December 30, the Federation held a joint session with Section L, Education, of the American Association for the Advancement of Science. The topic, the Problems of Science Teaching, was discussed by President Ira Remsen and Messrs. G. F. Stradling (Philadelphia), Wm. T. Campbell (Boston), John M. Coulter (Chicago), N. M. Fennemann (Cincinnati), and Lyman C. Newell (Boston). Their papers will be published in this Journal, that of President Remsen appearing in this issue. C. R. Mann, Secretary.

IOWA ASSOCIATION OF SCIENCE TEACHERS.

The Iowa Association of Science Teachers held its second annual meeting December 26, 1908. The first session opened at 9:30 A. M. in the Plymouth lecture room with President Frank F. Almy of Iowa College in the chair.

Professor W. S. Hendrixson of Iowa College read a paper on "The Ends to be Accomplished through the Teaching of Science in the Secondary Schools." He called attention to the fact that the ends are the same so far as concerns the elements whatever the grade of schools. The disciplinary value in the old sense of the term was not deemed of paramount importance, being an idea of science which ought to be regarded as a tenet of an educational childhood. Finally a knowledge of science is required for the best citizenship. Municipal problems are very largely economic and are based upon

scientific principles and require scientific treatment. Hence the need for an enlightened electorate.

The paper was discussed by Professor Hersey of Cedar Falls and Professor Norton of Cornell College. The latter called attention to the need of seeking out those who had scientific aptitudes and encouraging them to continue their science studies.

Principal Maurice Ricker of West Des Moines High School read a paper on "The Place of Science in the Balanced Secondary School Curriculum." Mr. Ricker called attention to the fact that untrained science teachers are not wholly to blame for the decline in the number of those pursuing science studies. The introduction of electives such as manual training and domestic science and the maintenance as constants of the prescribed languages and mathematics have had much to do with it.

If science were given an equal chance with other studies of the curriculum and not made an alternative of every popular elective, its continued place in the course would be assured. That science is not alone as a subject that is losing ground, as far as numbers taking it are concerned, is shown by the fact that in Boston where mathematics was made elective, from twenty-five to sixty-seven per cent take no mathematics in the first year.

Mr. S. L. Thomas of Council Bluffs read a paper on "The Corrective Value of Science in the High School." The speaker emphasized the fact that if science teaching is to result merely in the accumulation of facts and in the study of classified knowledge, it has no value not possessed by Latin or Greek.

It should be taught as a live, progressive subject and in such a way as to develop in the pupil the power of initiative and a spirit of independence.

The corrective value of science teaching depends largely on the teacher who may fail either because of too little or too much knowledge. The former is frequently not the teachers' fault as they are forced to undertake subjects which they know they are unqualified to teach.

The committee on "More Effective High School Instruction in the Sciences" made no formal report. Professor Almy was added to the committee and Principal Maurice Ricker was made chairman.

The following officers were elected for the ensuing year:

President, Professor J. L. Tilton, Simpson College, Indianola.

Vice-president, Mr. George W. Tidd, Fort Dodge.

Secretary-Treasurer, Mr. F. E. Goodell, North Des Moines High School.

Section Leaders: Physics, Professor L. Begeman, Cedar Falls; Chemistry, Miss Sara Nollen, West Des Moines High School; Biology, Miss Lena Barber, Sioux City; Physiography, Professor W. H. Norton, Cornell College, Mount Vernon.

It was voted to join the American Federation of Teachers of the Mathematical and the Natural Sciences, and Mr. F. E. Goodell was appointed delegate.

Chemistry Section.

The Chemistry Section was not largely attended as there are comparatively few schools in which the subject is taught; but those present, under the leadership of Professor A. A. Bennett of Iowa State College enjoyed a very helpful and interesting discussion on the relation of high school and college chemistry. It was agreed that it is unfair to the pupil who has had a good course in chemistry in the high school to be put in the same college class with the one who has never had the subject.

On motion of Mr. Goodell a committee consisting of Professor Bennett of Ames, Professor Hendrixson of Grinnell, Mr. Lafayette Higgins of West Des Moines, Mr. George W. Tidd of Fort Dodge, and Miss Emma Fordyce of Cedar Rapids, were appointed to formulate a plan of correlation of high school and college chemistry.

This committee is to report next year.

Physiography Section.

The Physiography Section met in West High School at 1:30 P. M. with Professor E. G. Cable of Cedar Falls in the chair.

The meeting was largely attended and proved very interesting and helpful.

Professor Tilton of Simpson College discussed the value of the lantern slide in the interpretation of topographic maps and in illustrating points brought out in field trips. When accompanied by questions and descriptions, they afford the best possible substitute for the field trip to regions too remote to be visited. They also prepare the student to recognize various features when he sees them in the field.

Miss Alison E. Aitchison of Cedar Falls emphasized the educative value of the field trip and insisted that we must get away from the old idea of geography as "a study of the earth in relation to man," but get the modern view that it is the study of the earth in relation to all life. The real question to-day is not, Shall we have field work? but How much shall we have and how shall we do it? These must be answered for the most part by each teacher, being conditioned by class, season, region, etc.

Some of the benefits to be expected from field trips are: (a) They help to make geography a live, vital subject, (b) they place it upon a more scientific basis, (c) they help to break up the idea that geography is a mere memory study.

Miss Blanche Noel's paper on the place of physiography in the course of study brought out much difference of opinion and a very heated discussion. Some favored the first year, others the second, and still others the fourth where it might be taken as an elective. Miss Noel emphasized its value as an introduction to other sciences and as a first year study because it is less strenuous and arouses interest in the natural world.

Physics Section.

There were about thirty-five high school, normal school, and college instructors in attendance at the meeting of the physics section which convened in Room 22, West Des Moines High School, at 1:30 P. M., December 29, 1908. Mr. George W. Tidd of Fort Dodge was in the chair. Mr. F. E. Goodell of North Des Moines High School opened the discussion of the "Value of Physics as Seen from the View Point of the Student." He gave a summary of the information of this subject that he had obtained in numerous interviews with high school students. It was to the effect that the chief value of the study of physics to the high school student lay in the training in habits of rigid accuracy in observation.

"The Value of Physics as Seen from the View Point of the Public and of the Instructor" was discussed by Professor Louis Begeman of the State Normal School and others. After which Profesor Arthur G. Smith of the State University presented a paper on the "Value of Physics as Seen from the View Point of the College," in which he urged the importance of keeping the subject free from the inaccuracies that might appear in attempting any departure from its treatment as a branch of applied mathematics. Professor A. A. Bennett of Iowa State College and others engaged in the discussion which followed in which the attempt to supplant pure physics with "phenomenology" was deplored. The sentiment of the meeting was finally expressed in the unanimous passage of a resolution introduced by Mr. F. E. Goodell, and reading as follows: "*Whereas,* The question of the nature of the instruction in physics is now a problem before the physics teachers of the country, therefore, be it *Resolved,* That it is the sentiment of the physics teachers of Iowa that the laboratory work should be essentially quantitative such as to develop accuracy with such qualitative experiments as may be necessary to bring out fundamental principles."

Mr. Lafayette Higgins of West Des Moines High School then exhibited an apparatus consisting of a glass track, brass ball, wooden block, and pendulum. He demonstrated its use in discussing "A Satisfactory Method for High School Experimentation in Uniformly Accelerated Motion." The simplicity of construction and ease of manipulation render this a very satisfactory piece of apparatus.

The topic of "Would it be Advisable to Offer Physics as an Elective to Girls?" was opened for discussion by Principal George Edward Marshall of Davenport High School. In his several years' experience as principal of some of the larger high schools of the state he had noted so many cases where general conditions were especially favorable in which girls seemed temperamentally unfit to take the course, and he felt that it was a waste of time to make it an absolute requirement for such students. This led to a very interesting and spirited discussion for and against the proposition, participated in by Professor Louis Begeman, Professor A. V. Storm, Miss Fordyce, Mr. Higgins, and others.

The session closed with the election of Professor Louis Begeman as leader for next year.

BIOLOGY SECTION.

The Biology Section met with the Physiography Section in the Natural Science Lecture Room at West High School. Professor L. E. Conklin of Drake University was leader.

Professor L. S. Ross of Drake University read a paper on the topic, "Should there be a Place in the High School Course for Instruction in Bacteriology and Elementary Medicine?" An abstract of the paper follows:

1. The highest degree of culture and the greatest practical efficiency attainable only in a healthy, normal body. If laws of nature are violated, whether willfully or through ignorance, the penalty will be exacted. Preventive medicine in ascendency. Better that in early life the citizen be taught the laws of health and the causes of disease than that he learn by experience. Many people skeptically ignorant, and many credulously ignorant.

2. Public health of economic importance, the well person a producer, the sick a consumer or at best only a partial producer. Citizen knowing causes of common diseases and the methods of distribution can intelligently aid in attempt toward better public health and in preventing spread of infectious diseases. Some knowledge of bacteriology necessary for intelligent coöperation with physicians and sanitarians. Practice of medicine revolutionized by science of bacteriology. Bacterial action concerned in many industries.

3. The course in bacteriology should present only the elementary facts and principles. Bacteria studied as other plans by laboratory methods. Attention given to the biology of the group. Conditions affecting growth illustrated by experimental observations. Principal work with non pathogens. Some observations on pathogens. Preparation of slides for microscopic study.

4. Apparatus for laboratory work simple and inexpensive. Culture media prepared by students. Sterilizers easily devised. Incubator, not a necessity, can be made at little cost. Much microscopic work may be done with one sixth inch objective.

Elementary course practicable for high school.

F. E. GOODELL.

SOUTH DAKOTA ASSOCIATION.

The South Dakota Association of Science and Mathematics Teachers held a second meeting for the year December 29 at Aberdeen, during the session of the state educational association. Arrangements were practically completed to hold future meetings with the state association. This insures success to the Association of Science and Mathematics Teachers. Our next meeting will be at Lead, S. D., next October.

L. E. ABELEY.

A COMMUNICATION.

In the January number of SCHOOL SCIENCE AND MATHEMATICS (Vol. IX, No. 1), p. 39, Gould describes "A Simple Plant Experiment" for removing carbon dioxide from the air surrounding a plant that has been making starch, to learn if the plant could make starch in the absence of this gas. The plant is placed under a bell-glass with an inlet tube passing into a jar of caustic potash or soda solution and a closing outlet tube through which the plant might be watered.

The comments (questions) of the Department Editor added to this short article interested me, especially the one involving the pedagogical principle: whether it is better to learn facts as direct statements from the teacher than to learn them from experiments that may be faulty. I cannot believe he would accept an affirmative answer as his question implies. How many high school or even college text-books of five to seven years ago did not have faulty experiments,* yet the principle was impressed as was intended. Of course this is not to be carried to a *reductio ad absurdum*, that any kind of slovenly apparatus may do as long as the ordinary student cannot discover the defects.

While the above was the main point that interested me, it may be remarked in passing that if the watering of the plant is carefully done in the experiment under consideration, no air need be introduced in this operation. The other objectionable part of the description that the Department Editor refers to, viz: "Air is forced through tube A for a few minutes until the most of the air in the bell-glass is devoid of carbon dioxide," does look inimical. It seems to me, however, that the experimenter has covered this point by leaving the experiment three days, insuring the removal of carbon dioxide by the alkali in the jar. Is it not, then, more a matter of statement than of actual defect in the experiment?

A more probable source of carbon dioxide is the earth or decaying matter in the flower pot. But this is provided against in the classical experiment by presence of plenty of soda lime. Would this not answer Professor Ganong's objection to this experiment raised in the article referred to in the footnote? L. M.

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*"The Erroneous Physiology of the Elementary Botanical Text-books," SCHOOL SCIENCE AND MATHEMATICS, April, 1906, p. 297.

volume answers with final authority all kinds of questions in language, the trades, arts and sciences, geography, biography, fiction, foreign words, etc. President Eliot of Harvard University fittingly says: *"The International is a wonderfully compact storehouse of accurate information."*

You will notice elsewhere in these columns that the publishers, G. & C. Merriam Co., of Springfield, Mass., offer to send specimen pages, etc. Mention this paper in your request and they will include a useful set of colored maps, pocket size. Do not longer delay owning an up-to-date dictionary.

Get The Best, which means the INTERNATIONAL.

PHOTO-MICROGRAPHY CATALOGUE.

For the first time a catalogue dealing exclusively with apparatus for PHOTO-MICROGRAPHY has been issued by the Bausch & Lomb Optical Co., Rochester, N. Y. This is the first catalogue of its kind issued in America, and all of the goods listed are made from raw materials by the company mentioned above.

Not only will the larger laboratories be interested in this publication, but those who have not so much time for this work will also find the new camera "Type H" admirably suited to their needs. A new series of lenses for Photo-Micrography known as the "Micro-Tessars" is introduced and an excellent half-tone of a section photographed with one of these low power objectives is used as a frontispiece. A new automatic electric lamp will be found of interest, as will also the new DDH microscope.

Those contemplating the addition of such an equipment will find this catalogue of interest and the price list, including recommended outfits, is arranged to materially assist in selecting the desired apparatus. This publication is sent gratis upon request to those interested.

BOOKS RECEIVED.

Control of Body and Mind, Vol. V. of the Gulick Hygiene Series, by Mrs. Frances Gulick Jewett. 12mo, cloth, 267 pages, illustrated; mailing price, 60 cents. Ginn & Company, Boston.

Essentials of Botany, by Joseph Young Bergen. 12mo, cloth, 380 pages, illustrated; mailing price, $1.30. Ginn & Company, Boston.

Report on the Illinois State Museum of Natural History, by A. R. Crook, Curator. Illinois State Journal Co., Springfield, Ill.

Handbuch für Physikalische Schülerübungen, Von Hermann Hahn, Professor am Dorotheenstädtirchen Realgymnasium und Leiter der praktischen Kurse für physikalische Schülerübungen in der Alten Urania zu Berlin. Mit 340 in den text gedruckten figuren. Berlin, Verlag von Julius Springer.

Arithmetical Abilities and Some Factors Determining Them, by Cliff Winfield Stone, Ph.D. pp. 101. 1908. Teachers College, Columbia University, New York City. Price, $1.00 postpaid.

BOOK REVIEWS.

The Romance of Mining, by Archibald Williams. Crown 8vo. cloth, gilt, illustrated. Pp. 402. $1.50 net. J. B. Lippincott Company, Philadelphia.

Under the heading "Fascinating Stories of Science," the J. B. Lippincott Company has published a series of "Romances" of which the volume "Romance of Mining" is one.

It is always a boon to the busy teacher to be able to refer a student to some particular book for a special topic and to know that he will find something not only to the point but in such a form that no urging is necessary in order to have the work done. No higher compliment could be paid to "The Romance of Mining" than to say it is such a book.

First, it gives specific information about many noted mines all over the world so selected that the reader learns methods of mining from the specific mine. Second, this information is put into delightful language with many side glimpses into history and geography, and in such simple and attractive form that the reader cannot drop the book, once started, without reading it from cover to cover.

In a brief review it is impossible to enumerate all the points which make this book valuable for every school library as well as a most acceptable gift book for any boy over twelve years old. The various Eldorados—California, Australia, South Africa, and Alaska—are strikingly described, the human element being kept clearly before the reader. The relation of the struggle for gold to history and geography is everywhere evident. The Comstock Lode, Real del Monte, Leadville all illustrate the extraction of silver; the Calumet and Hecla, and Rio Tinto that of copper; Almaden for quicksilver; Mesabi for iron; Cornwall for tin, and so on. A fact not commonly known is the supply of sulphur furnished by Japan, no less than 2,000 tons per month being produced by a single mine for a considerable period of time. The description of the salt mines of Wieliczka is simply astounding. Think of a body of salt 500 miles long, 20 miles broad, and 1,200 feet in thickness in which are ball rooms, chapels, and halls, cut from rock salt with ornaments of the same material. The account must be read to be appreciated.

This volume can be recommended to teachers of geography, history, and chemistry as just the right kind of outside reading for their pupils. Other volumes of the series will be reviewed in later numbers of this journal.

F. T. J.

The Foundations of Mathematics. A Contribution to the Philosophy of Geometry, by Dr. Paul Carus. Pp. 140. 75 cents. The Open Court Publishing Co., Chicago. 1908.

While many teachers of mathematics in the secondary schools are giving most of their time and thought to the practical side of their chosen vocation, it would doubtless be a distinct advantage to their work, as well as a pleasurable relief from a continuous study of the practical, if they would read this book and others on metageometry, foundations of mathematics

and the like. Dr. Carus has written an exceedingly interesting book. It is not above the comprehension of the high school teacher, and indeed, comes down to the practical at the close, where he says that in beginning geometry, "All instruction should consist in giving *tasks to be performed, not theorems to be proved;* and the pupil should find out the theorems merely because he needs them for his constructions." The topics considered are: The Search for the Foundations of Geometry, Historical Sketch. The Philosophical Basis of Mathematics. Mathematics and Metageometry.

The author says that he is not a mathematician by profession, but has come to the conclusion that the problem of philosophical basis of mathematics is not mathematical but philosophical. Since in speculations of this kind men arrive at different conclusions, it would be worth while to read some of the following books on various phases of this interesting subject.

Foundations of Geometry. Hilbert. $1.00. The Open Court Publishing Co.

Euclid's Parallel Postulate. Withers. $1.25. The Open Court Publishing Co.

Space and Geometry. Mach. The Open Court Publishing Co.

Common Sense of the Exact Sciences. Clifford. Appleton.

An Essay on the Foundations of Geometry. Russel.

Science and Hypothesis. Poincaré. Translated by Halsted, Science Press.

Rational Geometry. Halsted. $1.50. John Wiley and Sons.

Science Absolute of Space. Bolyai. Translated by Halsted.

Geometrical Researches in the Theory of Parallels. Lobatschewsky. Translated by Halsted.

Non-Euclidian Geometry. A text-book. Manning. 80 cents. Ginn and Co.

H. E. C.

First Course in Biology. Part I, Plant Biology, by L. H. Bailey; Part II, Animal Biology, and Part III, Human Biology, by W. M. Coleman. Cloth, 8vo, pp. XXV+204, 224, 164. Figs. 302, 408, 133+6 colored. $1.25. The Macmillan Co., 64 5th Ave., New York.

This text is offered as an attempt to bridge the chasm between the nature study of the grades and the formal science of the college or university. Each part is complete in itself and the order of subjects can therefore be arranged as the instructor thinks best. The work is supposed to require at least a year, in which case abridgment will be necessary, or a year and a half for completion of all the work.

Plant Biology begins with the ecological relations of the plant, then takes up the general morphology and organic functions of the spermatophytes, and closes with a series of studies of important cryptogams in ascending order. Animal Biology consists of a series of studies of the principal phyla of the animal kingdom, from the lowest to the highest. More than half the space is devoted to vertebrates. Human Biology is a brief consideration of the essentials of human anatomy and physiology, the viewpoint being the relation of man's life to the life of less highly developed organisms.

The writer believes that a larger amount of work could be included in Part I, especially along the line of physiological experimentation with plants, and that the evolutionary history of plants could be made more prominent with advantage. The development of sexuality in plants, the homology of the sexual processes in spermatophytes with those in the

higher cryptogams, and the development of the vascular system, are subjects of vast importance which could be emphasized by choosing cryptogamous examples which illustrate development rather than structure alone. My experience has been that this work is not too difficult if carefully presented. Of course, this extension would require more time for Part I, perhaps a full year, but I believe the extra time would be well spent.

A large amount of field observation and obtaining knowledge at first hand is required, the text is profusely illustrated, and careful suggestions are placed at the ends of chapters or incorporated in the text to guide the student in his work. These points will commend the book to those desiring an interest-arousing text-book on elementary biology.

No student can complete the work outlined without acquiring a wholesome spirit of openmindedness toward all natural phenomena, and a firm foundation in scientific methods of thinking and doing things, which are so essential in this age of scientific progress. C. A. S.

Practical Mathematics, by A. Consterdine and A. Barnes. 2s. 6d. Pp. XV +332. John Murray, London. 1908.

Teachers who are trying to unify secondary mathematics will find this book of much practical assistance to them. The following paragraph from the preface shows the spirit and method of the book. "The method adopted throughout the book is that the materials used for calculation shall be got for the most part from reasonably accurate measurements made by each student for himself, and that these measurements shall, as far as possible, be measurements of actual objects selected for the purpose. It will be found as a rule, that a definite sequence of operations is required of the student. That part of an object which is for the time under observation is carefully examined and described, then sketched, then measured, and then (if necessary) drawn to scale. Calculations arising out of the measurements are then made, each arithmetical and geometrical rule being considered as occasion requires, and stated, as often as not, as an algebraical formula. In other words, the several branches of elementary mathematics (measurement, drawing, arithmetic, geometry, algebra) are not merely correlated, but actually fused. One of the main features of the book is that when a fundamental principle of mathematics is under review, it shall be considered from as many different points of view as possible. It will, therefore, be understood that it will be neither necessary nor desirable that students shall receive separate lessons in Euclid, practical plane and solid geometry, geometrical drawing, algebra, or arithmetic while they are working through the course which is outlined in these pages. The authors have endeavored not only to amalgamate the various branches of mathematics, but to break down the water-tight compartments into which each of the branches is frequently divided." The chapters are as follows: The measurement of length: decimals. Curved lines: symbols. Vulgar fractions. Surfaces. The areas of rectangles. Drawing to scale. The unitary method: simple equations. Ratio: proportion: graphs. Angular measurement. Indices and logarithms. The areas of triangles and polygons. Squares on the sides of a triangle: multiplication and division in algebra. The areas of circles and curved surfaces. Solids: plans, elevations, and sections. Volume and weight. Similar triangles. Trigonometry. Time and velocity. H. E. C.